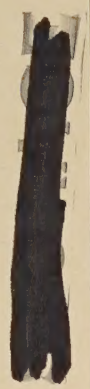
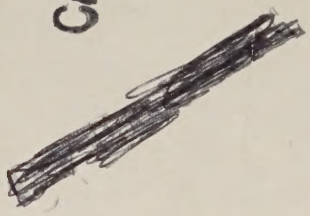
ACPL ITEM
DISCARDED

Automatic telephone practice

665247
*
621.385 H43
PUBLIC LIBRARY
Fort Wayne and Allen County, Ind.
EXTRACTS FROM RULES
A fine of two cents a day shall be paid on each volume not returned when book is due. Injuries to books, and losses must be made good. Card holders must promptly notify the Librarian of change of residence under penalty of forfeiture of card.
EXTRACT FROM STATE LAW
Whoever shall wilfully or mischievously, cut, mark, mutilate, write in or upon, or otherwise deface any book, magazine, newspaper, or other property of any library organized under the laws of this state, shall be fined not less than ten dollars nor more than one hundred dollars.
Acme Library Card Pocket
KEEP YOUR CARD IN THIS POCKET
LIBRARY BUREAU CAT. NO. 1165
OVERSIZE
DO NOT REMOVE CARDS FROM POCKET



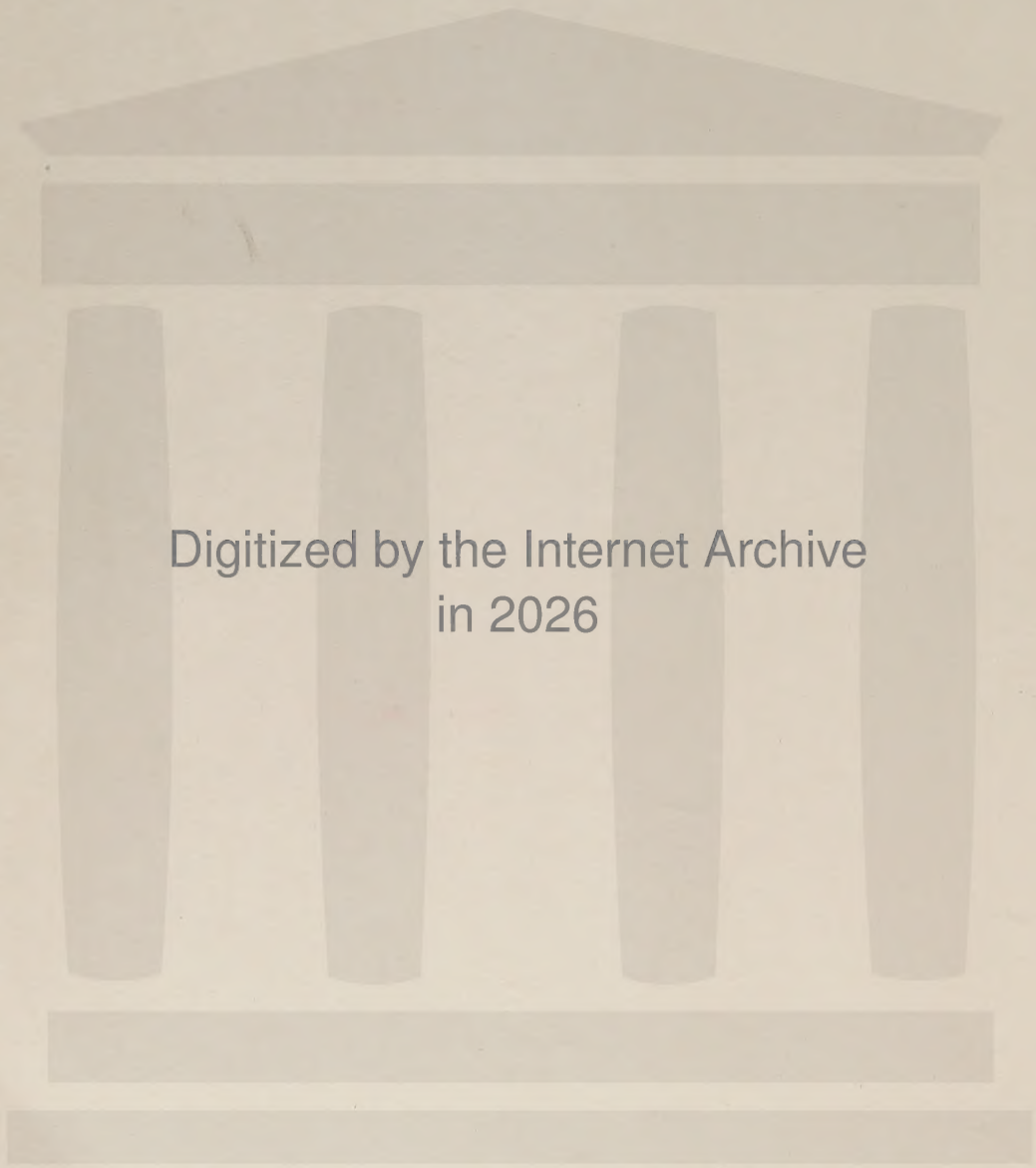




ACPL ITEM
DISCARDED







Digitized by the Internet Archive
in 2026

https://archive.org/details/automatictelepho0000harr

# AUTOMATIC TELEPHONE PRACTICE

SIXTH EDITION

BY

HARRY E. HERSHEY

*621.385
H43
BLACK GOLD

PRICE $6.00

(We pay Domestic Postage
on Prepaid Orders)

Published By-

"TECHNICAL PUBLICATIONS" P.O. BOX 68.

WHITEWATER, KANSAS.

COPYRIGHT, 1917,
COPYRIGHT, 1919,
COPYRIGHT, 1920,
COPYRIGHT, 1924,

By Harry E. Hershey

COPYRIGHT, 1946
COPYRIGHT, 1949

By

Mildred Hershey
Donna Hershey

Printed and Bound in the United States of America

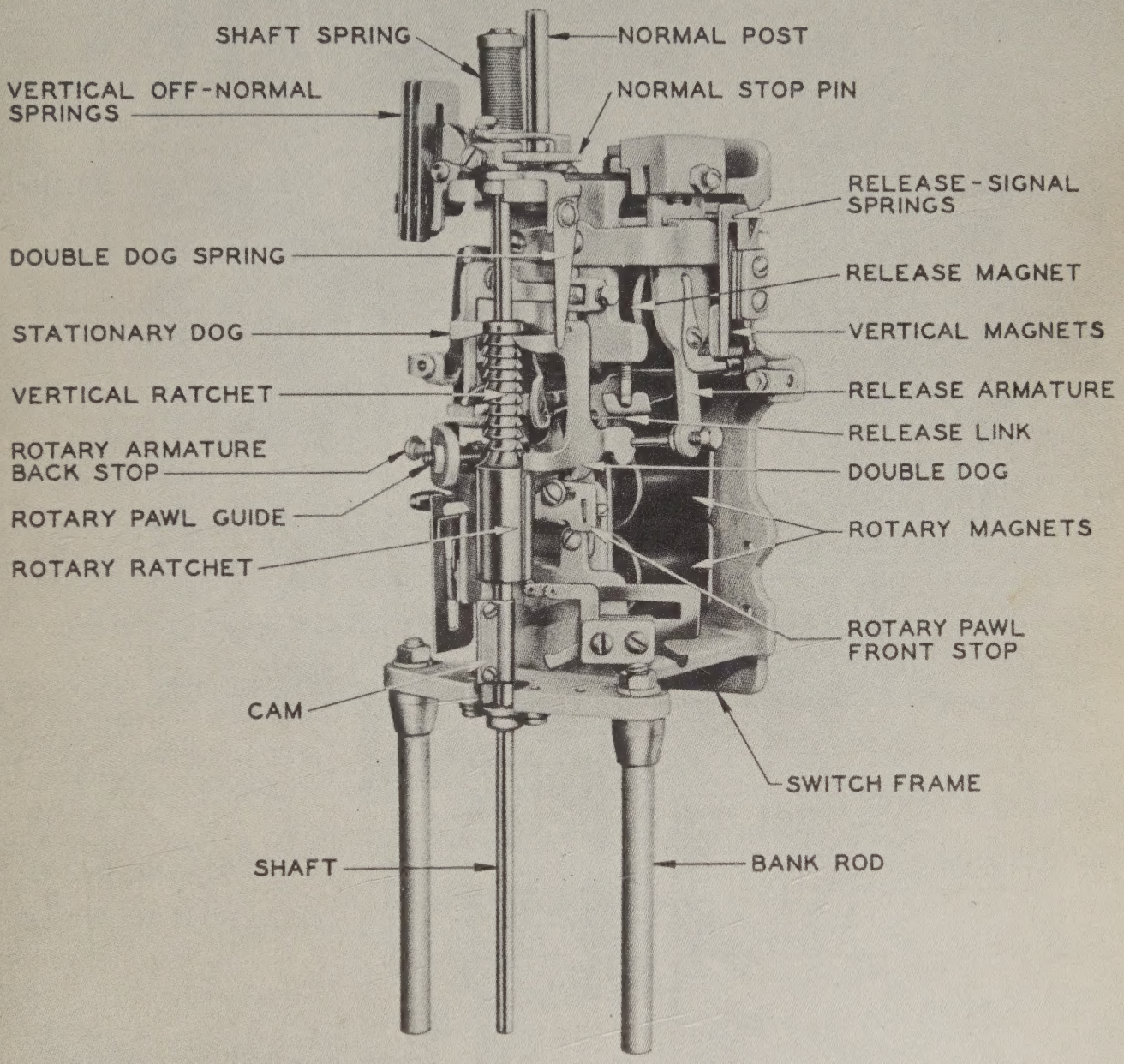



PLATE A - Strowger Switch Mechanism. This Universal Switch may be used as a Line-Finder, as a Selector, as a Connector, and as a Remote Control Unit.

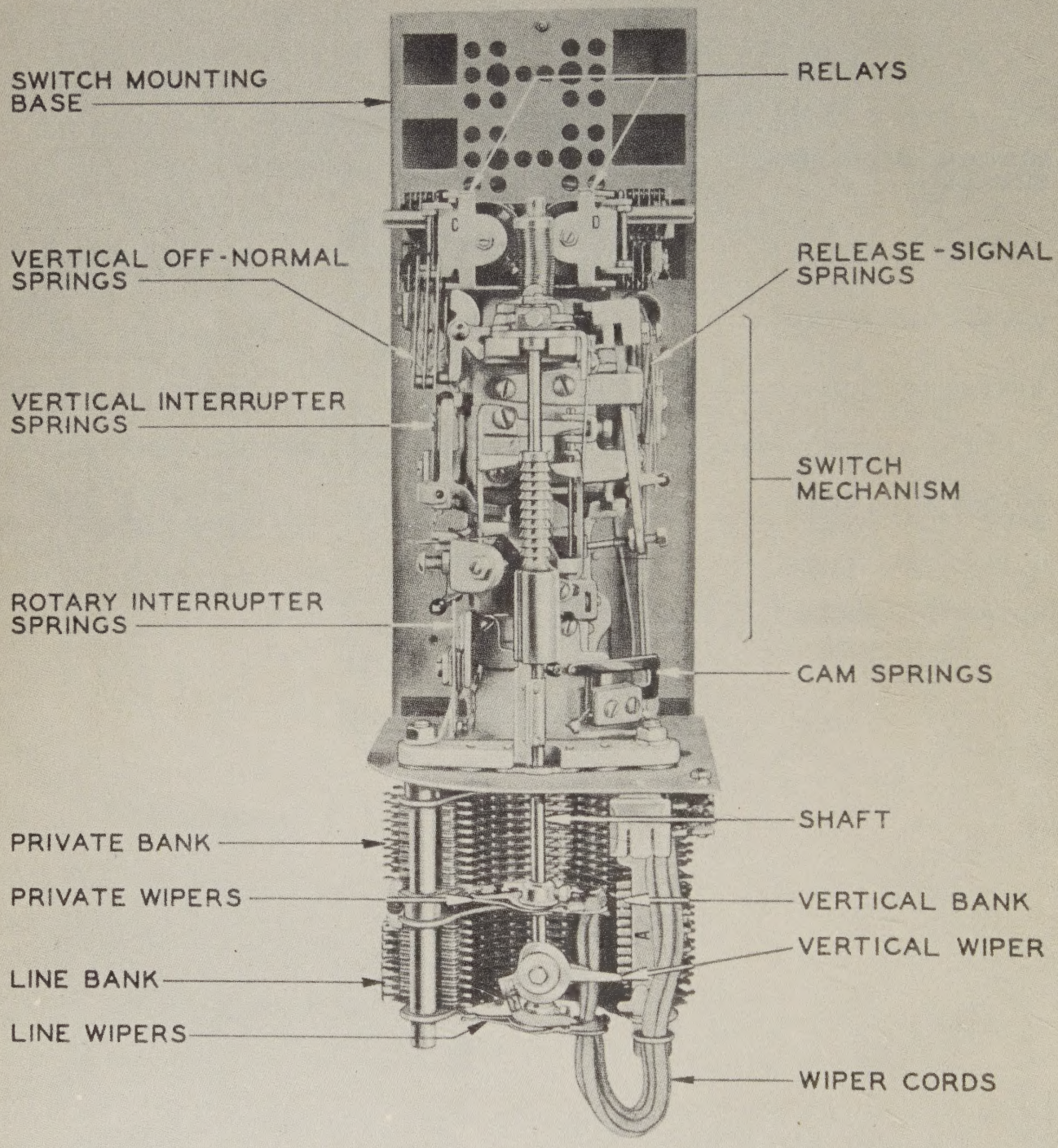



PLATE B - Strowger Line-Finder Switch. This switch accomplishes a connection in two motions - first the "vertical" motion and then the "rotary" motion at right angles to it.

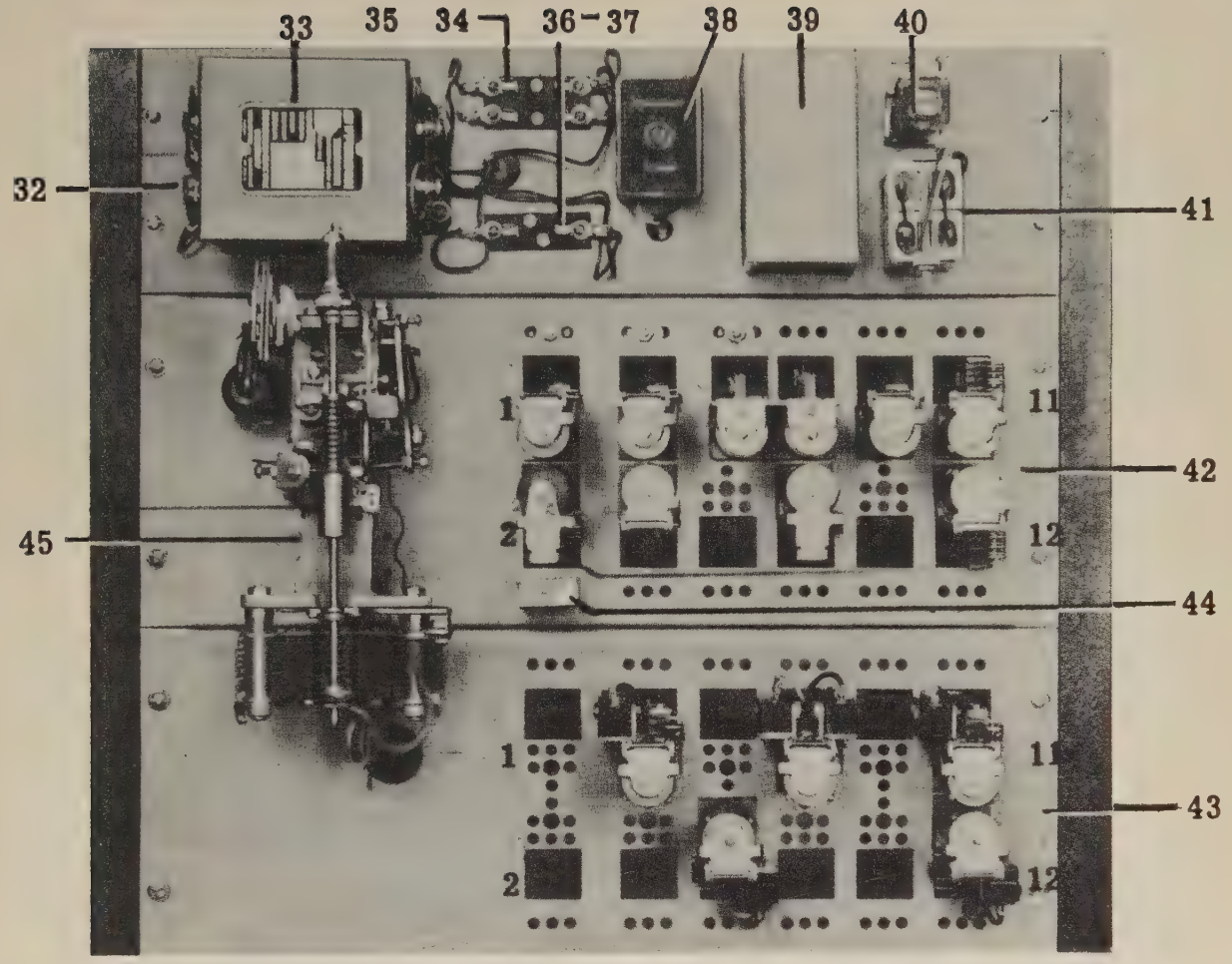



PLATE K - Strowger Mechanism Used As A Remote Control Unit.

- Equipment at Control Quarters. A dial permits remote control of circuits incidental to radio transmitter operation by an operator at Control Quarters. A handset permits modulation of the distant transmitter with speech input originating at Control Quarters. A dial chart exhibits information for dialing into the two-motion Strowger switch for the purpose of setting up various circuit combinations.

- Equipment At Transmitter Station. The Strowger switch (45) operates as described in Sec. 324(a), page 86. The interlocking relays (42, 43) operate as described in Sec. 324, page 86.

# FOREWORD

Those who are familiar with the Sherlock Holmes tradition may recall that Doctor Watson once attempted to catalog Holmes' personal and professional abilities with the intent of finding out just what useful purpose Holmes could possibly serve in a civilized society. After making a categorical listing of the topics on which Holmes appeared to be best informed, the good doctor, in despair and frustration, threw the list into the fire, unable to reconcile those abilities with any well-defined human need.

I once tried the same sort of experiment with Harry Hershey, and the results seemed to me equally fruitless. He is the first to admit that he can't write. Often, when he has asked me to edit his work - and Heaven knows it needs editing - he has said to me, "How in thunder did I get into this writing game anyway?" His phrasing is at once amateurish and pedantic. He has a casual disregard for ordinary syntax. He uses punctuation not to make sense, but merely to break the monotony of words. His spelling has neither the charm of originality nor the consistency of being phonetic. True, he knows something about the telephone business, but then so do thousands of other people.

Now I submit there is nothing in all this that might plausibly support the premise that Hershey has any business in publishing a textbook on Automatic Telephony (or anything else for that matter), or that his success in that venture would have been so great as to stir him to the publication of a sixth edition.

But facts are stubborn things! This is the sixth edition, and Hershey doesn't publish his book for sheer pleasure. While I expect a complimentary autographed copy in return for this frank Foreword, I warrant that few others will be so favored. Make no mistake about it; Hershey will make money out of this edition, just as he has out of all the others, despite his frequent ravings against the fruits of private enterprise - that is, the other fellow's private enterprise.

Well, just what is it that Hershey does have? Why is he able to continue selling this book of his? I can think of several possible explanations. One is that the telephone industry has never been singularly favored with good textbooks; which is another way of saying that Hershey hasn't had much competition. The plain fact is that there hasn't been a really well-written book on Telephony since McMeen and Miller's 1912 edition, on which I cut my own eye teeth.

But I don't want to rob Hershey of all the credit for his success in the publishing game. One thing in his favor is that he undoubtedly has a flair for teaching, which is excellent background for the writing of any technical treatise. Here's a bit of history to illustrate what I mean.

'Way back in the early twenties, I had the job of teaching a group of students some of the basic principles of the Strowger System. I found it a rather discouraging task. After wearing my fingers to the bone with chalk and blackboard, and talking myself hoarse for an hour trying to explain how a connector works, I turned to the class expecting to find some glimmer of comprehension. Blank stares were all I got; and the only remark, "Looks like a lot of spaghetti to me". To this day, I can't look at a circuit without thinking of spaghetti.

Not long after this, Hershey had the job of teaching a similar class, and one day I sneaked in to watch him suffer. But he wasn't suffering. He was enjoying it; so were the students. They showed not only keen interest but also a fair degree of comprehension. Some of them, by the way, were Western Electric employees, which, according to Hershey, didn't make the job any easier. So it appears that one of the qualities that Hershey has is what might be called the "pedagogical instinct". Perhaps there is something of that nature in his book. I sincerely hope so, although I have no intention of reading it to find out.

But perhaps Hershey's greatest saving grace is his sincere and unbounded admiration for the Strowger System, which is the sole subject of his book. He has worked with it, and with the people who made it what it is, ever since his days at the Kansas "cow college". He has seen other systems come into being and struggle vainly for supremacy, but to Hershey the Strowger System still towers far above them all. We have no disposition to argue with him on that point, and the occasional brave soul who suggests that he ought to say something about newer systems gets a rebuff that is characteristic of Hershey in his less gentlemanly moments.

Apart from all this, Hershey's book is quite unlike any other technical book I ever saw. It may well be that I had something to do with that too. I remember saying to him one time, "Harry, next time you publish your book, put something in it besides the dry-as-dust mechanical and circuit details that other books on telephony have. Bait it with some human interest stuff that will get people to read it." Now my remark was made in perfect innocence and good faith, and I wasn't suggesting that he should go berserk the way he did with his fifth edition, using it as a crusading vehicle for his amateurish political philosophy, most of which I am inclined to think is a cloak for his own laziness and ineptitude. Perhaps he has concluded that such vaporings have no place in a technical book. Whatever the reason, you won't find much of it in this edition. Anyway, if Hershey thinks this Foreword is a better space filler, who am I to argue with him?

But, after all, what you will want to know most about this book is whether you are going to get your money's worth. My guess is that you will. But if you conclude otherwise, don't try to get your money back. I forgot to mention that Hershey is also qualified to practice law.

La Grange Park, Illinois
February 10, 1949

H. E. Clapham

## PREFACE TO SIXTH EDITION

The present high price of paper and composition very definitely limits the number of pages that can go into a text book to sell at an established price. For this reason "Caveat Emptor" and the non-technical sections of "Part B - Historical" have been deleted to make way for more technical matter in the Sixth Edition of this text.

So much remains to be said and so few years are left the writer, that it seems expedient to follow the plan of the earlier editions - significant fundamentals plainly presented in order that the student may acquire a background which will permit later specialization in his chosen branch of the art.

The Sixth Edition is greatly enlarged (256 pages as compared with the 160-page fifth edition), and actually presents 112 new pages covering circuit and technical discussion. The new coverage includes, among other things, complete circuit descriptions of a typical Local Test Desk and associated switch train, a toll switch train and many special connectors.

Appendix "G" - Typical Adjustments, made possible by courtesy of Automatic Electric Company, presents a wealth of information for the student who is interested in mechanical details.

Appendix "H" - Elementary Principles, discusses elements of the telephone instrument, the Strowger mechanism, and relays as used in Strowger telephone practice.

The appendixes became available too late for incorporation in the general index, but see the table of contents on page XVI and the special index on page G-00.

By the way, just what is this sin tax that Herb. talks about in the Foreword? Could it be a new Federal tax?

Harry E. Hershey

Chicago, Ill.
March 1, 1949

# PART A - GENERAL


| SECTION | | PAGE |
|---|---|---|
| 100 | SUBSCRIBER STATION EQUIPMENT | 1 |
| 101 | THE DIAL | 1 |
| 102 | GROUPING OF SUBSCRIBERS | 2 |
| 102(a) | Illustration | 2 |
| 102(b) | Proscess of Elimination | 2 |
| 102(c) | Million Number System | 3 |
| 102(d) | Lettered Dial | 3 |
| 102(e) | Smaller Systems | 3 |
| 103 | STROWGER MECHANISM | 3 |
| 104 | THE STROWGER BANK | 4 |
| 105 | STROWGER CONNECTOR | 4 |
| 106 | NON-NUMERICAL SWITCHES | 5 |
| 106(a) | Strowger Line Finder | 6 |
| 107 | FINDER-CONNECTOR LINK | 7 |
| 108 | FINDER DISTRIBUTER | 7 |
| 109 | THE 200-LINE FINDER | 7 |
| 110 | STROWGER SELECTOR | 7 |
| 111 | THE IMPULSE REPEATER | 8 |
| 112 | TRUNKING WITHIN THE OFFICE | 8 |
| 112(a) | Grading | 9 |
| 113 | INTER-OFFICE TRUNKING | 9 |
| 113(a) | The Director | 9 |
| 114 | SWITCH TRAINS | 10 |
| 115 | THE LOCAL SWITCH TRAIN | 10 |
| 116 | THE TOLL SWITCH TRAIN | 10 |
| 117 | THE TEST SWITCH TRAIN | 10 |
| 118 | PARTY LINE SERVICE | 10 |
| 119 | AIR CONDITIONING | 10 |
| 120 | ANNOYANCE TRAP | 11 |
| 120(a) | Fire or Police | 11 |
| 121 | ASSISTANCE SERVICE | 11 |
| 122 | AUTOMATIC SWITCHING OF TOLL LINES | 11 |
| 122(a) | Loop Dialing | 11 |
| 122(b) | Composite Dialing | 11 |
| 122(c) | A. C. Dialing | 11 |
| 122(d) | Voice Frequency Dialing | 11 |
| 123 | AUTOMATIC TOLL BOARD | 11 |
| 124 | AUTOMATIC TOLL TICKETING | 12 |
| 125 | THE C. A. X. | 12 |
| 126 | THE CALL INDICATOR | 12 |
| 127 | CLASS OF SERVICE TONES | 12 |
| 128 | CODE CALL SERVICE | 12 |
| 128(a) | Code Call Via The Connector | 13 |
| 129 | COMPLAINT OBSERVATION | 13 |
| 130 | THE CONDENSER | 13 |
| 131 | CONFERENCE SERVICE | 14 |
| 131(a) | "Meet Me" | 14 |
| 131(b) | Progressive | 14 |
| 131(c) | "Fixed Group" | 14 |
| 132 | CONNECTORS OF LARGE CAPACITY | 1 |
| 132(a) | Wiper Selection Made at Banks Of Preceding Switch | 1 |
| 132(b) | Wiper Selection Made Within Connector | 1 |
| 132(c) | By use of Counting Relays | 1 |
| 132(d) | By Use of Minor Switch | 1 |
| 132(e) | 200-Line Connector Having 20 Rotary Steps | 1 |
| 133 | CONNECTORS OF SMALL CAPACITY | 15 |
| 133(a) | Using 11-Point Rotary Switch | 15 |
| 133(b) | Using 25-Point Rotary Switch | 15 |
| 134 | CONVERSATION TIMING | 1 |
| 134(a) | Link Timing (Line Lock Out) | 1 |
| 135 | DIAL CONTROLLED RINGING | 1 |
| 136 | DIRECT LINE SERVICE | 1 |
| 136(a) | Executive Key-Calling Service | 1 |
| 136(b) | Executive Loudspeaking Direct Line System | 1 |
| 137 | DISCRIMINATING SERVICE | 1 |
| 138 | EXECUTIVE "RIGHT OF WAY" | 1 |
| 138(a) | Using Individual Connector | 1 |
| 138(b) | Using Common Connector | 1 |
| 139 | FIRE ALARM | 1 |
| 140 | FLOOR PLANS | 1 |
| 141 | IMPULSES, LIGHT & HEAVY | 1 |
| 142 | INFORMATION SERVICE | 1 |
| 143 | INTERCEPTING SERVICE | 1 |
| 144 | LINE & TRUNK STANDARDS | 1 |
| 145 | LOCK PULSING | 1 |

146 MESSAGE REGISTERS . . . . . 17

147 THE MINOR SWITCH . . . . . 17

148 MONITORING SERVICE . . . . . 18

149 MULTIPLE MARKINGS . . . . . 18

150 OUTGOING SECONDARY LINE SWITCHES . . . . . 19

151 PAY STATIONS . . . . . 19

152 THE P.A.B.X. . . . . 20

152(a) Passing Call Feature . . . . . 20

153 THE P.A.X. . . . . 20

153(a) Small P.A.X's. . . . . 20

153(b) Moderate & Large P.A.X's. . . . . 20

153(c) Special Services . . . . . 20

154 PICK-UP SERVICE . . . . . 21

155 NIGHT ANSWERING AND TRANSFER SERVICE . . 21

156 POWER . . . . . 21

156(a) The Battery, and Voltage Control . . 21

156(b) End Cells . . . . . 21

156(c) Counter Cells . . . . . 21

156(d) Full-Float Operation . . . . . 22

156(e) High-Low-Voltage Controlled Charging 22

156(f) Battery Eliminators . . . . . 22

156(g) Functions of the Battery . . . . . 22

157 PRELIMINARY IMPULSES . . . 22

158 PUSH BUTTON RINGING . . . . 22

159 THE R.C.X. . . . . 23

160 RADIO INTERFERENCE . . . . 23

161 THE RELEASE LINK . . . . . 23

162 RESTRICTED SERVICE . . . . . 23

163 REVERTING CALLS . . . . . 23

164 THE ROUTINER . . . . . 23

165 SERVICE OBSERVATION . . . . 23

166 SIMPLEX DIALING . . . . . 24

167 SLUGLESS PULSING . . . . . 24

168 SPLASH RING . . . . . 24

169 SUPERVISORY EQUIPMENT . . . 24

170 TIME SERVICE . . . . . 25

171 TONES . . . . . 25

172 TRAFFIC METERS . . . . . 25

173 TRAFFIC STUDIES . . . . . 25

174 WATCHMENS SERVICE . . . . . 26

174(a) P.A.B.X. Recording Type . . . . 26

174(b) Combined Recording & Supy. Service . 26

175 CONNECTORS PECULIAR TO P.A.B.X's . . . . . 26

175(a) Impulse Repeating on Trunking Levels 26

175(b) Switching through on Trunking Levels . 26

176 CALL INDICATOR EQUIPMENT . . 26

177 THE LINE SWITCH . . . . . 27

178 KEITH LINE SWITCH . . . . . 27

178(a) Line Switch Mechanism . . . . . 28

178(b) Master Switch Mechanism . . . . 28

178(c) Line Switch Boards . . . . . 28

179 ROTARY LINE SWITCH . . . . . 29

180 SECONDARY LINE SWITCH . . . . 29

180(a) Method of Trunking to Secondary Line Switches . . . . . 30

180(b) Primary to Secondary Line Switch Combinations . . . . . 30

181 OUTGOING SECONDARY LINE SWITCHES . . . . . 31

181(a) Used With Selectors . . . . . 31

181(b) Used With Switching Selector Repeaters 31

182 LINE ADAPTORS . . . . . 31

183 CALL RECORDER . . . . . 32

184 LINE I.D.F. FACILITIES . . . . 32

184(a) Cabling Plan Without Line I.D.F.Facilities . . . . . 32

184(b) L.I.D.F. Facilities . . . . . 32

(A) Increase in Efficiency of Outside Plant . . . 32A

(B) Re-Distribution of Originating Traffic 32A

(C) Reduction in Amount of Line Equipment Required . . 32B

(D) Provisions for Changes in Classes of Service . . 32A

184(c) L.I.D.F. Plans . . . . . 32A

184(d) Typical Full L.I.D.F. Plan . . 32B

185 TRUNK TERMINATION . . . 32B

185(a) Termination on Subscribers Line Equipments . . . 32B

185(b) Incoming Switch Termination Method . . . . . 32C

(A) Discriminating Service . . 32C

(B) Universal Numbering . . . 32C

185(c) Comparative Advantages . . 32C

186 RACK MOUNTED EQUIPMENT . .32C

186(a) Details of Trunking . . . . .32D

187 DIAL-BACK EQUIPMENT . . .32D

# PART B - HISTORICAL


| SECTION | | PAGE |
|---|---|---|
| 200 | SUBSCRIBER STATION EQUIPMENT | 33 |
| 201 | THE DIAL | 33 |
| 201(a) | Non-Returnable Dial | 33 |
| 201(b) | Standard Dial | 33 |
| 201(c) | Delayed Impulse Dial | 33 |
| 201(d) | Thousand Year Dial | 33 |
| 201(e) | Quieted Dial | 33 |
| 201(f) | Sanitary Dial | 34 |
| 201(g) | Autodial | 34 |
| 202 | GROUPING OF SUBSCRIBERS | 34 |
| 203 | STROWGER MECHANISM | 34 |
| 203(a) | B.P.O. Version | 35 |
| 204 | THE STROWGER BANK | 35 |
| 204(a) | Mahoney's Switch | 36 |
| 204(b) | Three 200-Contact Banks | 36 |
| 204(c) | Michrophonic Noise | 36 |
| 204(d) | B.P.O. Switch & Bank | 36 |
| 205 | STROWGER CONNECTOR | 36 |
| 205(a) | Connector Functions | 36 |
| 205(b) | Seizure | 37 |
| 205(c) | Sequential Operation | 37 |
| 205(d) | Connecting Wipers to Called Line | 37 |
| 205(e) | Connector Normals, Open or Closed | 37 |
| 205(f) | Testing Called Line For Busy | 37 |
| 205(g) | Prevention of Further Rotation | 37 |
| 205(h) | Ringing the Called Line | 37 |
| 205(i) | Ringing Generator | 37 |
| 205(j) | Battery or Ground Connected | 37 |
| 205(k) | Instantaneous Ring-Cut-Off | 38 |
| 205(l) | Ring Back Tone | 38 |
| 205(m) | Draining Condenser Charge | 38 |
| 205(n) | Answering Supervision | 38 |
| 205(o) | Booster Battery Metering | 38 |
| 205(p) | Last Party Release of Connector | 38 |
| 205(q) | First Party Release of Switch Train | 38 |
| 206 | STROWGER LINE FINDER | 38 |
| 206(a) | The 100-Line Finder | 39 |
| 206(b) | Preferential Hunting | 39 |
| 206(c) | Dial Tone | 40 |
| 207 | FINDER-CONNECTOR LINK | 40 |
| 208 | FINDER DISTRIBUTER | 40 |
| 209 | THE 200-LINE FINDER | 41 |
| 209(a) | Preferential Hunting | 41 |
| 209(b) | Theoretic Grouping | 42 |
| 209(c) | Actual or Numerical Grouping | 42 |
| 209(d) | Mechanical Arrangement | 44 |
| 209(e) | Line Relays | 44 |
| 209(f) | Line Finder | 44 |
| 209(g) | Group Relays | 44 |
| 209(h) | Distributer | 44 |
| 209(i) | Functions | 44 |
| 209(j) | Line Relays | 44 |
| 209(k) | Line Finder | 44 |
| 209(l) | Group Relays | 45 |
| 209(m) | Distributer | 45 |
| 210 | STROWGER SELECTOR | 45 |
| 210(a) | Cut-In | 45 |
| 210(b) | Automatic Rotary | 45 |
| 210(c) | Searching For Absence of Ground | 45 |
| 210(d) | Battery Searching | 45 |
| 210(e) | Stopping on First Idle Trunk | 45 |
| 210(f) | By De-Energization of Relay | 46 |
| 210(g) | By "Pull-Up" of Relay | 46 |
| 210(k) | Powell Selector | 46 |
| 210(i) | 10/20 Selector | 46 |
| 210(j) | Major Functions of Selector | 46 |
| 210(k) | Digit Absorbing Selector | 46 |
| 211 | THE IMPULSE REPEATER | 46 |
| 211(a) | One-Way Impulse Repeater | 47 |
| 211(b) | Functions | 47 |
| 211(c) | Two-Way Impulse Repeater | 47 |
| 210(d) | Citations | 47 |
| 211(e) | Selector Repeater | 47 |
| 211(f) | Switching Selector Repeater | 47 |
| 211(g) | Trunk Economy | 47 |
| 211(h) | Three Types | 48 |
| 211(i) | Second Digit Type | 48 |
| 211(j) | Functions | 48 |
| 211(k) | Citations | 48 |
| 211(l) | True Two-Way Impulse Repeater | 48 |
| 212 | TRUNKING WITHIN THE OFFICE | 49 |
| 212(a) | Bank Slip | 49 |
| 212(b) | Slip Between Shelves | 49 |
| 212(c) | Grading | 49 |
| 212(d) | Terminal Assemblies | 50 |
| 212(e) | Citations | 50 |
| 212(f) | Citations | 50 |
| 212(g) | Bell Equipment School | 50 |
| 213 | INTER-OFFICE TRUNKING | 50 |
| 213(a) | Outgoing Secondary Line Switches | 51 |
| 213(b) | The Director | 51 |
| (A) | Illustration | 51 |
| (B) | Ingenuity | 52 |
| 213(c) | Interconnection, Auto. & Manual | 53 |
| 213(d) | Manual to Automatic | 53 |
| 213(e) | Automatic to Manual | 53 |
| 213(f) | Universal Numbering & Digit Absorption | 54 |
| 213(g) | Citations | 54 |
| 214 | SWITCH TRAINS | 55 |
| 215 | THE LOCAL SWITCH TRAIN | 56 |
| 215(a) | Regular Straight Line Connector | 56 |
| 215(b) | Local Trunk Hunting Connectors With Night Service Feature | 56 |
| (A) | Number Assignment | 56 |
| (B) | Trunk Hunting Function | 56 |
| (C) | Another Method of Establishing Groups | 56 |
| (D) | Night Service for P.B.X. Trunk Groups | 56 |

(E) Conn. Having Night Service Feature . 56
(F) Conn. Without Night Service Feature . 57
(G) Groups of More Than Ten Trunks But Not to Exceed Twenty . . 57
(H) Disconnect Supervision to Called Manual Exchange . . . 57
215(c) Local Level Hunting Connectors With Night Service Feature . 57
(A) Number Assignment . . . . . 57
215(d) Bank Arcs . . . . . 57

216 THE TOLL SWITCH TRAIN . . . 58
216(a) Toll Transmission Selector . . . 58
216(b) Toll Connector . . . . . 58
216(c) Combination Local & Toll Regular Connector . . . 59
(A) Seizure Supervision . . . . 59
(B) Flash Busy . . . . . 59
(C) Toll Offering Service . . . . 59
(D) Camp-On-Busy . . . . . 59
(E) Toll Break Down (Disconnect) . . 59
(F) Delayed Ring . . . . . 59
(G) Re-Ring . . . . . 60
(H) Answering Supervision . . . . 60
216(d) Combination Local & Toll Trunk-Hunting Connector . . . 60
216(e) Toll Level-Hunting Connector . . 60
216(f) Combination Local & Toll Level-Hunting Connector . . . 60

217 THE TEST SWITCH TRAIN . . . 60
217(a) Test Distributer . . . . . 60
(A) Test for "Busy Test Connector". . 61
(B) Test Connector Becomes Idle . . 61
(C) Impulsing Test Connector . . . 61
(D) Test for Busy Line . . . . . 61
(E) Called Line Becomes Idle . . . 61
(F) Further Rotation of Test Connector . 61
(G) Release of Test Connector Only, or Release of Entire Train . . 61
(H) Verification Service . . . . . 61
(I) Verification Circuit . . . . . 61
217(b) Test Connector . . . . . 61
217(c) Combination Local & Test Connector . 62

218 PARTY LINE SERVICE . . . . 62
218(a) Terminal Per Station Service . . 62
Two-Party, Divided Ringing, Selection Made in Connector Bank, M.A.X. 62
(B) As Above, For P.A.X's . . . 62
(C) Five-Party Harmonic, Metallic Ringing, Selection Made By Preceding Switch . . . 62
(d) Two-Party Divided Ringing, Selection Made by Preceding Switch . 63
218(b) Terminal Per Line Service . . . 63
(A) Two-Party, Divided Ringing . . 63
(B) Frequency Selecting Connector . . 63
(C) Frequency Selection Last . . . 63

218(c) Reverting Calls . . . . . 63
(A) By Special Number . . . . . 63
(B) By Prefix to Directory Number . . 64
(C) By Directory Number . . . . 64
218(d) Code Ringing . . . . . 64
(A) Two Codes Only (1-Ring or 2-Rings) 64
(B) The Two-Ring Connector . . . 64
(C) Code Selecting Connector . . . 65
(D) 10-Party Code Selecting Connector, Frequency Last . . . . 65
(E) Delayed Ring . . . . . 65

277 THE LINE SWITCH . . . . . 65

278 KEITH LINE SWITCH . . . . . 65
278(a) 3-Wire Line Switch . . . . . 66
278(b) Single Coil Line Switch . . . . 66
278(c) 2-Coil Line Switch . . . . . 66
278(d) Self Aligning Line Switch . . . 67

279 ROTARY LINE SWITCH . . . . 67

280 SECONDARY LINE SWITCH . . . 68
280(a) Pick-Up Service . . . . . 69

290 LOCAL TEST DESK . . . . . 69
290(a) Classes Of Calls . . . . . 69
291 Incoming Calls To Test Desk . . 69
291(a) Incoming Call Wire . . . . 69
291(b) Incoming From Selector Levels . 69
(A) Inspector's Trunks (Circuit) . 69
(B) Seizure . . . . . 69
(C) Answering . . . . . 69
(D) Holding . . . . . 70
(E) Release . . . . . 70
292 Test Desk Cord Circuits . . . 70
292(a) The Service Cord . . . . . 70
(A) Incoming Call, Answering . . 70
(B) Incoming Call, Extending . . 70
293 Outgoing Calls From Test Desk . 70
293(a) Outgoing Call Wire . . . . 70
293(b) Outgoing Via Service Cord . . 70
293(c) Outgoing Trunk To Test Distributer (Circuit) . . 71
(A) Seizure . . . . . 71
(B) Dialing . . . . . 71
(C) Testing, "Out" Test . . . 71
(C1) "In" Test . . . . . 71
(C2) Permanent Disconnect . . 71
(C3) Monitoring Subscribers' Call . 71
(D) Dialed Connector Or Line Busy . 72
(E) Holding Connection When Connector Is Busy . . . 72
(F) Holding Connection On Idle Line . 72
(G) Releasing Connector From Busy Line . . . . . 72
(H) Release Of Test Connector Only . 73
(I) Release Of Test Switch Train . 73
293(d) Test Line To MDF . . . . 73
294 Test Circuits . . . . . 73
294(a) Primary Test Cord . . . . 73
294(b) Auxiliary Test Cord . . . . 73
294(c) Interchange Key . . . . . 74
295 Tests . . . . . 74
295(a) With Primary Test Cord . . . 74
295(b) With Auxiliary Test Cord . . 74
296 Testing Combinations . . . . 74
297 Testing . . . . . 74

# PART C - CIRCUIT KINKS


300 SEARCHING CIRCUITS . . . . . 77
301 Searching for Absence of Ground . . 77
301(a) Switch Advances Upon De-Energization of Motor Magnet . 77
301(b) Switch Advances Upon Energization of Motor Magnet . 77
302 Battery Searching . . . . . 78
302(a) First Illustration . . . . . 78
302(b) Second Illustration . . . . . 78
303 Searching for Ground . . . . . 79
304 "All Relay" Searching Circuit . . 79
304(a) "All Relay" Distributer . . . . 79
(A) Selection of Next Idle Finder . . 79
(B) Next Finder Busy . . . . . 80
(C) Distributer Operation When Last FD Relay Operates . . 80

305 DRIVING CIRCUITS . . . . . 80
305(a) Pulses . . . . . 80
306 Temporator Driving Circuit . . . 80
307 3-Wire Driving Circuit . . . . . 81
308 2-Wire Driving Circuit . . . . . 81
309 "All Relay" Driving Circuits . . 81
310 Two Relays Per Step . . . . . 82
310(a) Second Illustration . . . . . 82
311 One Relay Per Step . . . . . 82
311(a) Relay Behind Cut Off . . . . . 82
311(b) Endless Counting Chain . . . 82

312 RESTORING CIRCUITS . . . . . 82
312(a) The Strowger Release Circuit . . 82

313 IMPULSE GENERATORS . . . . . 83
313(a) Speed . . . . . 83
313(b) Pulse Ratio . . . . . 83
313(c) Impulse Generation . . . . . 83
314 First Illustration . . . . . 83
315 Second Illustration . . . . . 83
316 Third Illustration . . . . . 83

317 DELAYED RELAY OPERATION . . 84
318 Operate Time Delay . . . . . 84
318(a) Weighted Spring . . . . . 84
318(b) Variable Resistance Around Condenser 84

319 RELEASE TIME DELAY OF RELAY . 84
319(a) Vibrating Reed . . . . . 84

320 COMBINED OPERATE AND RELEASE TIME DELAY . . 84

321 PULSE REPEATER CIRCUITS . . 84
321(a) Pulse Shortening . . . . . 84
321(b) Pulse Stretching . . . . . 84

321(c) ALTERNATE OPEN & CLOSE RELAY COMBINATIONS . . 85

322 LOCK PULSING CIRCUITS . . . 85
322(a) Light Pulses . . . . . 85
322(b) Heavy Pulses . . . . . 85

322(c) DIAL SPEED RANGE . . . . . 85

323 PULSE CUT-IN CIRCUITS . . . 86

324 INTERLOCKING RELAYS . . . . 86

324(a) REMOTE CONTROL CIRCUIT . . . 86
325 LOCK OUT CIRCUITS . . . . . 86
325 LOCK OUT CIRCUITS . . . . . 86

326 COUNTING & TOTALIZING . . . 86
327 Counting . . . . . 86
328 Totalizing . . . . . 86

329 IN AND OUT CIRCUITS . . . . 87
329(a) First Illustration . . . . . 87
330 Wheels Counted . . . . . 87
331 Direction Established . . . . 87
331(a) First Illustration . . . . . 87

332 ALARM CIRCUITS . . . . . 88

333 NON-TELEPHONE PATENTS . . . 88
334 Numerical List of Patents . . . 89
33

335 STEPPING SWITCHES . . . . . 90
335(a) Around and Return . . . . . 90
335(b) Unidirectional Rotary . . . . 91
335(c) Up. Around & Return . . . . 91
(A) Sequence Switch . . . . . 91
(B) Toggle Action of Rotary Interrupter . 91
(C) 3-Wire Driving Circuit . . . 91
(D) Searching For Absence of Ground . 91


# PART D - CIRCUITS


400 SUBSCRIBER STATION CIRCUITS . . 93
400(a) The Dial . . . . . 93
(A) Delayed Impulse . . . . . 93
400(b) Circuit Reading of Line and Release Relay . . . 93
400(c) Modern Telephone Circuit . . . 94

401 LINE CIRCUITS . . . . . 94
401(a) Used With Plunger Line Switch . . 94
(A) When Calling . . . . . 94
(B) Restoration of Receiver . . . 94
(C) When Called . . . . . 94
(d) Illustration of Closed Normals . . 94
401(b) As Above But With Open Normals . 94
401(c) Used With Non-Homing Rotary Line Switch . . . . . 94
401(d) Used With Rotary Finder . . . 94
401(e) Used With Strowger Finder . . . 95
401(f) Line Lock-Out Circuit . . . . 95

402 NON-NUMERICAL SWITCH CIRCUITS . 95
402(a) Keith Line Switch Circuit . . . 95
402(b) Master Switch Circuit . . . . 97
402(c) Self Aligning Line Switch Circuit . . 99
402(d) Rotary Line Switch Circuit . . . 100
(A) Relay Assembly . . . . . 100
(B) Mechanism . . . . . 100
(C) Functions . . . . . 100
(D) Circuit Reading . . . . . 101
(E) Seizure . . . . . 101
(F) Seeking An Idle Trunk . . . 101
(G) Engaging Idle Trunk . . . . 101
(H) Switching Through . . . . 101
(I) Restoring Electrical Circuit to Normal . . . . . 101
(J) Incoming Calls . . . . . 101

403 SELECTOR SWITCH CIRCUIT . . . 102
403(a) Seizure . . . . . 102
403(b) Raising Shaft & Wipers to Dialed Level . . . . 102
403(c) Cutting In on Dialed Level . . . 103
403(d) Trunk Hunting . . . . . 103
403(e) Returning Busy Tone if all Trunks are Busy . . . 103
403(f) Seizing the First Idle Trunk . . . 103
403(g) Release . . . . . 103
(A) From All Trunks Busy Condition . 103
(B) From Completed Call . . . . 104
403(h) Permanent Alarm . . . . . 104
403(i) Selector Release Alarm . . . . 104
403(j) Busy Key . . . . . 104
403(k) Test Jack . . . . . 104
403(l) Spark Suppresion . . . . . 105

404 CONNECTOR SWITCH CIRCUIT . . 105
404(a) Seizure . . . . . 105
404(b) Vertical Stepping . . . . . 105
404(c) Rotary Stepping . . . . . 106
404(d) Trunk Hunting . . . . . 106
404(e) Switching Through to the Called Line . . . . . 107
404(f) Answering . . . . . 107
404(g) Transmission . . . . . 107
404(h) Returning Busy Tone for Busy Condition . . . . 107
404(i) Executive Right of Way . . . . 107
404(j) Release . . . . . 108
404(k) Release From Completed Call . . 108
(A) Calling Party Disconnects First . 108
(B) Called Party Disconnects First . 109
404(l) Release From Busy . . . . . 109
404(m) Permanent Alarm . . . . . 109
404(n) Busy Key . . . . . 109
404(o) Spark Suppresion . . . . . 109

405 FINDER SWITCH CIRCUIT . . . 111
405(a) Finding the Calling Line . . . . 111
(A) Seizure . . . . . 111
(B) Vertical Hunting . . . . . 111
(C) Rotary Hunting . . . . . 113
(D) Switching Through . . . . . 113
(E) Selection of Next Idle Finder . . 115
(F) Next Finder Busy . . . . . 115
(G) Distributer Operation When Last FD Relay Operates . . 115
(H) Release . . . . . 115
(I) Transferring Future Calls of "Group A" to "Group B" . . 117
(J) Failure of Vertical or Rotary Stepping . . . . . 117
(1) If a Finder is Free in Group B . 117
(2) If all Finders are Busy in Group B . 119
(K) Failure of a Finder to Find a Line . 119
405(b) Calls to the Subscriber . . . . 119
405(c) Executive Right of Way . . . . 119
405(d) Start & Level Marking Circuit . . 119
405(e) All Finders Busy . . . . . 121
405(f) More Than One Call Received At a Time . . . . . 121
405(g) Finder Blocked Key . . . . . 121
405(h) Test Jack . . . . . 121
405(i) Spark Suppression . . . . . 121

406 IMPULSE REPEATER CIRCUIT . . 122
406(a) Circuit of One Way Repeater . . . 122
(A) Seizure . . . . . 122
(B) Loop to Distant Office . . . . 122
(C) Impulse Repeating . . . . . 123
(D) Talking Circuit . . . . . 123
(E) Releasing . . . . . 124
406(b) Circuit of Two Way Repeater . . 124

407 SPECIAL CIRCUIT FEATURES . . 125

408 CONN. OF UNUSUAL CAPACITY . 125
408(a) Ten- Line System . . . . . 125
(A) 10-Line Connector, CIRCUIT . . 125
(B) 10-Line Finder, CIRCUIT . . . 126
(C) Auxiliary Equipment, CIRCUIT . 127
(C1) Ringing Converter, CIRCUIT . . 128

408(b) 22-Line Connector, CIRCUIT . . 128

408(c) 200-Line Connector, CIRCUIT . . . 129
(A) Selection at Banks of Preceding Sw. 129
(B) Selection Within The Connector . 130
(B1) By Use Of Counting Relays . . 130
(B2) By Use Of Minor Switch . . . 130

(C) 190- Line Connector . . . . . 131

409 Trunk- Hunting Connector, CIRCUIT 131
409(a) Without Night Service Feature . 132
409(b) Second Illustration . . . . 132
409(c) With Night Service Feature . . 133
(A) Calling Individual Line . . . 133
(B) Calling Pilot Number . . . 133

410 Level-Hunting Connector, CIRCUIT . 134
410(a) Relay Chart . . . . . 135

411 TOLL SWITCH TRAIN . . . . 136
411(a) Toll Transmission Selector, CIRCUIT 136
(A) Seizure . . . . . 136
(B) Vertical Stepping . . . . . 136
(C)) Automatic Rotary Searching . . 137
(D) ATB, "Flash Busy" . . . . . 137
(E) Seizing First Idle Trunk . . . 137

(F) Completing The Connection . . 138
(G) Line Seizure Supervision . . . 138
(H) Called Line Busy . . . . 138
(I) Ringing The Called Line . . . 138
(J) Answering . . . . . 138
(K) Disconnect Supervision . . . 139
(L) Re-Ringing Called Line . . . 139
(M) Re-Ringing PBX Trunk . . . 139
(N) Release Of Completed Connection . 139
(O) Release From Busy . . . . 140
(P) Intercept Service . . . . 140
(Q) Coin Controll . . . . . 140

411(b) Toll Connector, CIRCUIT . . . 141
(A) Seizure . . . . . 141
(B) Testing Called Line . . . . 141
(C) Called Line Free . . . . 141
(D) Ringing & Ring-Back Tone . . 142
(E) Called Party Answers . . . 142
(F) Release . . . . . 142
(G) Called Line Busy . . . . 142

411(c) Combination Connector, CIRCUIT . 142
(A) Local Seizure . . . . . 143
(B) Vertical Stepping . . . . 143
(C) Rotary Stepping . . . . 143
(D) Called Line Busy . . . . 143
(D1) Called Line Idle . . . . 144
(E) Answering . . . . . 144
(F) Transmission . . . . . 144
(G) Release . . . . . 144
(G1) Calling Party First . . . 144
(G2) Called Party First . . . 145
(G3) From Busy . . . . . 145
(G4) From Abandoned Call . . . 145
(H) Toll Seizure . . . . . 145
(I) Vertical Stepping . . . . 145
(J) Rotary Stepping . . . . 145
(K) Testing Called Line . . . . 145
(K1) Called Line Busy . . . . 145
(K2) Called Line Idle . . . . 145
(L) Ringing . . . . . 145
(M) Answering . . . . . 145
(N) Transmission . . . . . 145
(O) Re-Ringing . . . . . 145
(P) Release . . . . . 145

411(d) Individual Toll Connector, CIRCUIT . 146
(A) Vertical Stepping . . . . 146
(B) Rotary Stepping . . . . . 146
(C) Called Line Busy . . . . 146
(D) Camp On Busy . . . . . 147
(D1) Ringing After . . . . . 147
(E) Toll Offering . . . . . 147

412 TEST SWITCH TRAIN . . . . 147
412(a) Test Distributer, CIRCUIT . . . 148
(A) Seizure . . . . . 148
(B) Vertical Stepping . . . . 148
(C) Cutting-In On Dialed Line . . 148
(D) Testing Trunk To Test Connector . 148
(D1) Test Connector Idle . . . . 148
(E) Repeating Impulses . . . . 149
(F1) Called Line Busy . . . . 149
(F2) Camp On Busy . . . . . 149
(F3) Release Of "Permanent Line" . 14
(G) Called Line Idle . . . . . 14
(H) "In" & "Out" Tests . . . . 15
(I) Release of Test Connector Only . 15
(J) Release of Entire Switch Train . 15
(K) Dialed Test Connector Busy . . 15
(L) Use of Connector Selector . . 15
(M) Verification Service . . . . 15

412(b) Test Connector, CIRCUIT . . . 15
(A) Seizure . . . . . 15
(B) Advancement of Wipers . . . 15
(C) Testing Called Line . . . . 15
(D) Release . . . . . 15

413 PARTY LINE SERVICE . . . . 151

414 Terminal Per Station Service . . 151
414(a) Two-Party, Divided Ringing . . 151
(A) Selection Made Within The Conn. . 151
414(b) Five-Party Harmonic . . . 151
414(c) Two-Party, 1-Ring & 2-Ring . . 151
414(d) Four-Party, 1-Ring & 2-Ring . . 152

415 Terminal Per Line Service . . . 152
415(a) Two-Party, Divided Ringing . . 153
(A) Selection Made by Preceding Sw. . 153
(B) Selection Made Within Connector . 153
415(b) Frequency Selecting Connector . 153

415(c) Code Ringing, 10-Party, CIRCUIT . 154
(A) Seizure . . . . . 154
(B) Vertical Motion . . . . 154
(C) Rotary Motion . . . . . 154
(D) Selecting Ringing Code . . . 154
(E) Seizing Called Line . . . . 155
(F) Ringing Called Line . . . . 155
(G) Called Party Answers . . . 155
(H) Release . . . . . 155
(H1) Calling Party First . . . 155
(H2) Called Party First . . . 155
(I) Called Line Busy . . . . 155
(J) Reverting Call By Directory Number . . . 155
(J1) Called Party Answers . . . 156
(J2) Release . . . . . 156

415(d) Code Ringing, Dial Controlled CKT. . 156
(A) Ringing Called Party . . . . 156
415(e)
415(e) Code Ringing, Push Button Controll . 156
(A) Individual Connector, CIRCUIT . 156
(B) Seizure . . . . . 156
(C) Vertical Stepping . . . . 156
(D) Rotary Stepping . . . . 156
(E) Over-Ride Of Busy . . . . 156
(E) Seizing Called Line . . . . 156
(G) Ringing Called Line . . . . 156
(H) Transmission . . . . . 157
(J) Release . . . . . 157

416 Reverting Calls . . . . . 157

417 Reverting Call By Special Number . 157
417(a) 2-Party, Divided Ringing, CKT. . 157

(A) Seizure . . . . . 158
(B) Calling Party Replaces Receiver 158
(C) Ringing Called & Calling Stations 158
(D) Receiver Removed . . . 158
(E) Both Receivers Replaced . . 158
(F) Rlease of Reverting Call Trunk . 158
(G) Line Lock-Out . . . . . 158

(b) 10-Party, Divided Ringing, CKT. . 158
(A) Seizure . . . . . 159
(B) Selecting First Frequency . . 159
(C) Selecting Second Frequency . 159
(D) Calling Party Replaces Receiver 159
(E) Ringing . . . . . 159
(F) Receiver Removed . . . 160
(G) Both Receivers Replaced . . 160
(H) Line Lock-Out . . . . . 160

8 Reverting Call By Prefix To Directory Number . . 161
8(a) Digit Absorption . . . . . 161
8(b) Conversation Timeing . . . 161
8(c) Code Ringing . . . . . 161

8(d) 20-Party Bridging, 10-Party Divided, CIRCUIT . . . 162
(A) Seizure . . . . . 162
(B) First Digit Dialed . . . . 162
(C) Second Digit Dialed . . . 162
(D) Third Digit Dialed . . . . 163
(E) Fourth Digit Dialed . . . 163
(F) Fifth Digit Dialed . . . . 163
(G) Calling Party Replaces Receiver 163
(H) Ringing Called Station . . . 164
(I) Called Party Answers . . . 164
(J) "Timing Out" . . . . . 165

19 Reverting Call By Directory Number 165

20 CONNECTORS PECULIAR TO PABX'S 165

21 Impulse Repeating, CIRCUIT . . 165
21(a) Code Call Service . . . . . 165
(A) Seizure . . . . . 166
(B) Vertical & Rotary Movement . 166
(C) Testing Code Call Circuit . . 166
(D) Code Call Circuit Free . . . 166
(E) Repeating Impulses . . . . 166

21(b) "Meet-Me" Conference Service . 167
21(c) Night Number Service . . . 167
21(d) Watchman's Recording Service . 167
21(e) Trunk-Hunting on OGT Level . . 167
(A) Automatic Cut-In . . . . 167
(B) Searching For Idle Trunk . . 168
(C) Seizing First Idle Trunk . . 168
(D) Repeating Impulses . . . . 168

21(f) Annunciator Service . . . 168

22 Switching Through, CIRCUIT . . 169
22(a) Discriminating Service . . . 169
22(b) Outgoing Calls . . . . . 169
(A) Raising Wipers to OGT Level . 169
(B) Discrimination . . . . . 169
(C) Calling Line Entitled to OGT . 170
(D) Searching For Idle Trunk . . 170
(E) Seizure of First Idle Trunk . . 170
(F) All OGT Busy . . . . . 170
(G) Releasing . . . . . 170
22(c) Hunt-The-Not-Busy-Line . . . 171
(A) Ringing First Idle Line in Group . 171
(B) Called Party Answers . . . 171
22(d) Code Call Service . . . . . 171
22(e) Conference Service . . . . . 171

23 EXECUTIVE "Right-Of-Way" . . 171
24 Using Individual Connector . . 171
25 Using Common Connector . . . 171
(A) Seizure . . . . . 172
(B) Vertical & Rotary Motion . . 172
(C) Testing Called Line . . . . 172
(D) Called Line Busy . . . . 172
(E) "Over-Ride" of Busy . . . 172
(F) Camp-On-Busy . . . . . 172

26 CODE CALL SERVICE . . . 173
26(a) Register-Sender . . . . . 173
26(b) Seizure . . . . . 173
26(c) Operation of Sender . . . . 173
26(d) Answering Code Call . . . . 174

27 CONFERENCE SERVICE . . . 174
27(a) "Meet-Me" Conference . . . 174
27(b) Fixed Group Conference . . . 174
(A) Seizure. . . . . 174
(B) Ringing All Stations . . . . 175
(C) Transmission . . . . . 175
(D) Release of Individual Station . . 175
(E) Release of Control Station . . 175
27(c) Progressive Conference . . . 176
(A) Seizure. . . . . 176
(B) Rotary and Vertical Motion . . 176
(C) Testing Called Line . . . . 176
(D) Called Line Idle . . . . . 177
(E) Ring-Back Tone . . . . . 177
(F) Digit Absorption. . . . . 177
(G) Transmission . . . . . 177
(H) Calling Other Parties . . . 177
(I) Releasing . . . . . 177

28 TRAFFICORDER . . . . . 177

29 TRUNKING, Inter-Office . . . 177

30 P.A.B.X. . . . . 177

31 ROTARY LINE SWITCH . . . 177

32 THE DIRECTOR . . . . . 177

33 THE MODERN DIRECTOR . . . 178
33(a) Translation . . . . . 178
33(b) Alternative Routing . . . . 178
(A) Secondary Routing . . . . 179
(B) Tertiary Routing . . . . 179
(C) Passing Connections . . . . 179
33(c) Citation . . . . . 179

434 DIALING METHODS . . . . . 179

435 DRY-TRUNK REPEATER . . . . 179

436 LOCK PULSING . . . . . 179

437 AUTOMATIC SWITCHING OF TOLL LINES . . . . . 180

438 STROWGER BANK. . . . . 180
438(a) Strowger Mechanism . . . . . 180

439 TRUNKING WITHIN THE OFFICE . 180

440 PROGNOSTICATION . . . . . 180
Automatic Pulsing on Carrier Current Telephone Channels. 180
Switching Selector Repeaters In Multi-Office Networks . . 180
Mobile Radio System, Ft. Wayne . 180
Intercepting Service As Applied to Automatic Systems. . . . 180
Super-Imposed Ringing . . . . 180


## APPENDIX "G"

(Courtesy of Automatic Electric Company)

TYPICAL ADJUSTMENTS


A-000 Sequence of Strowger Switch Inspection . . G-1
A-100 General Requirements . . . . G-6
A-101 Shelf Jacks, Covers, Bases & Busy Keys . . G-7
A-110 Horizontal Relays, Single Contact . G-9
A-120 Off-Normal Springs . . . . G-15
A-121 Shaft Spring Assemblies . . . G-16
A-122 Cam Spring Assemblies . . . G-16
A-130 Vertical Mechanism . . . . G-17
A-131 Switch Dogs . . . . . G-18
A-132 Rotary Mechanism . . . . . G-19
A-133 Release Mechanism & Springs . . G-20
A-135 Shafts, Wipers & Banks. . . . G-21
A-136 Minor Switch . . . . . G-23
A-173 Horizontal Relays, Twin Contact . G-25
A-805 Dial . . . . . G-28


## APPENDIX "H"

ELEMENTARY PRINCIPLES


1. Introduction . . . . . G-31
1.2 Explanation of Drawings . . . G-31

2. Telephone System . . . . . G-31

3. Telephone Instrument . . . . G-32
3.1 Handset . . . . . G-32
3.2 Transmitter Unit . . . . . G-32
3.3 Receiver Unit . . . . . G-3
3.4 Dial. . . . . G-3
3.5 Cradle Switch . . . . . G-3
3.6 Ringer . . . . . G-3
3.7 Condensers . . . . . G-3
3.8 Induction Coil . . . . . G-3

4. Telephone Circuit . . . . . G-3
4.1 Dialing Circuit . . . . . G-3
4.2 Ringing Circuit . . . . . G-3
4.3 Transmission Circuit . . . . G-3
4.4 Receiving Circuit. . . . . G-3

5. Functions of the Automatic Switchboard . . G-3

8. Mechanics of the Strowger Switch . G-3
8.3 Switch Mechanism . . . . . G-3
8.31 Shaft & Hub. . . . . G-3
8.32 Vertical Motion . . . . . G-3
8.33 Rotary Motion . . . . . G-3
8.34 Release Action . . . . . G-3

8.4 Spring Assemblies . . . . G-3
(a) Off-Normal Springs . . . . G-3
(b) Cam Springs . . . . . G-3
(c) Interrupter Springs . . . . G-3
(d) Release-Signal Springs . . . G-3

8.5 Switch Jacks . . . . . G-3
8.6 Relay Mountings . . . . . G-3
8.7 Test Jack . . . . . G-3
8.8 Busy Key . . . . . G-3

9. Mechanics of the Minor Switch . . G-3

10. Mechanics of the Relay . . . . G-40
10.1 Coil. . . . . G-40
10.2 Heelpiece . . . . . G-40
10.3 Armature . . . . . G-41
10.4 Spring Assembly . . . . . G-41
10.5 Spring Adjustments . . . . G-41
10.6 Slow-Acting Relays . . . . G-42

10.7 Special Relays . . . . . G-43
(a) Short-Lever Armature Relay . . G-43
(b) Double Armature Relay . . . G-43
(c) Two-Step Relay . . . . . G-43
(d) Twin Contact Relay . . . . G-43
(e) Type "Z" Relay. . . . . G-43

11. "AH" Sheets . . . . . G-44

12. "MD" Drawings . . . . . G-45

## A

AER - See Publications.
AETJ - See Publications.
AT - See Publications.
STJ - See Publications.
A. C. Dialing, 11.
Adapters, 31.
Air Conditioning, 10.
Andersen, 3.
Andres, 85.
Annoyance Trap, 11.
Annunciator Service, 168.
Arcs, Bank, 57.
Assistance Service, 11.
Autodial, 34.

AUTOMATIC -
Electric Review - See Publications.
Electric Technical Journal - See Publications.
Rotary, 45, 77, 78, 92, 103.
Switching of Toll Lines, 11, 180.
Toll Board, 11.
Toll Ticketing, 12.

Axelson, 50.

## B

B. P. O. (British Post Office) Switch, 35, 36, 45, 57.
Baer, 33, 50, 55.
Bakker, 48.

BANK -
Arcs, 57.
Connector Numbering, 4.
Multipled, 5, 9, 49.
Slip, 49.
Strowger, 4, 35, 180.

Barry, 12.

BATTERY -
Booster Metering, 38.
Controlled Charging, 22.
Counter-Cells, 21.
Eliminators, 22.
End Cells, 21.
Full Float Operation, 22.
Voltage Controll, 21.
Voltage Controlled Charging, 22.

Bell Laboratories Record, 65.
Bell System Technical Journal, 50.
Booster Battery Metering, 38.
Brown, 3.
Bulkley & Durand, 3.
Burfeind, 3.

BUSY -
Camp-On, 59, 147, 149, 172.
Flash, 58, 137.
Over-Ride of, 157, 172.
Test, Regular, 37, 107.
Test, Toll, 61, 138.
Tone, 128.

## C

C. A. X. (Community Automatic Exchange), 12.
Restricted Service, 23.
Supervisory Equipment, 24.

Cadden, 22.
Calculation of Switch Quantities, 36, 50.
Calhoun, 17.
Call Indicator, 12, 26, 54.
Call Recorder, 32.
Call Wire, 69, 70.
Camp-On-Busy, 59, 147, 149, 172.
Campbell, 3, 55.
Catchpole, 10.
Charging Batteries, 22.
Christus Victor, 161.

CIRCUIT KINKS -
2-Wire Driving Ckt., 81.
3-Wire Driving Ckt., 81.
Alarm Circuits, 88.
"All Relay" Distributer, 79.
"All Relay" Driving Ckt., 81.
"All Relay" Searching Ckts., 79.
Alternate Open & Close Ckts., 85.
Automatic Rotary, 77, 78.
Battery Searching, 78.
Counting Ckts., 86.
Counting Relays, 81.
Delayed Relay Operation And Release, 84.
Detached Ckt. Diagrams, 77, 136.
Dial Speed Range, 85.
Direction Established, 87.
Driving Circuits -
2-Wire, 81.
3-Wire, 81, 92.
"All Relay", 81.
Switch, 80.
Tele-Chec, 80.
Temperator, 80.

Heavy Pulses, 85.
Impulse Generators, 83.
In-And-Out Ckts., 87.
Interlocking Relays, 86.
Light Pulses, 85.
Lock-Out Ckts., 86.
Lock Pulsing Ckts., 85.
Non-Telephone Patents, 88.
Operate Time Delay, 84.
Pulse -
Cut-In Ckts., 86.
Generators, 83.
Light & Heavy, 85.
Ratio, 83.
Repeater Ckts., 84.
Shortening Ckts., 84.
Stretching Ckts., 85.

Release Ckts., 82.
Release Time Delay, 84.
Remote Control Ckts., 86.
Restoring Ckts., 82.
Rotary Interrupter, 77, 92.
Sequence Switch, 91.
Searching Circuits -
"All Relay", 79.
Battery Searching, 78.
For Absence of Ground, 77, 92.
For Ground, 79.

Stepping Switches, 90.
Stopping Ckts., 78.
Switches -
"Around & Return", 90.
"Unidirectional Rotary", 91.
"Up, Around & Return", 91.
Tele-Chec System, 80, 85.
Temporator Driving Ckt., 80.
Totalizing Ckts., 86.
Wheels Counted, 87.

Circuits, Line, 94, 111.
Circuits, Suscriber Station, 93.

CIRCUITS, SWITCH -
Connector Sw. Ckt., 105.
Finder Sw. Ckt., 111.
Keith (Plunger) Line Sw. Ckts., 95.
Line Ckts., 94.
Master Sw. Ckt., 97.
Repeater Ckts., 122, 124.
Rotary Line Sw. Ckt., 100.
Selector Sw. Ckt., 102.
Self-Aligning Line Sw. Ckt., 99.

Clapham, 4, 8, 10, 19, 22, 23, 25, 30, 34, 38, 50, 67, 81.
Clare, 45, 67.
Clark, 48, 55.
Class of Service Tones, 12.
Code Call, 12, 13, 165, 171, 173.
Code Ringing, 64, 161.
Coin Controll, 140.
Complaint Service, 11.
Complaint Observation, 13.
Composite Dialing, 11.

CONDENSER -
Draining Charge, 38.
Spark Protection, 13, 105, 109, 121.

Conference Service, 14, 174.
Fixed Group, 174.
Meet-Me, 167.
Progressive, 176.

CONNECTOR -
2-Ring, 64, 152.
10-Line, 125.
22-Line, 128.
190-Line, 131.
200-Line, 14, 15, 129.
P. A. B. X. 26, 165, 177.
P. B. X., 56.
Bank Numbering, 4.
Circuit, 105.
Code Call Via., 13.
Code Selecting, 65, 154, 164.
Combination Local, 59, 142.
Combination Test, 62.
Combination Level-Hunting, 60.
Combination Trunk-Hunting, 60.
Frequency Selecting, 63, 153.
Group, 56.
Hunt-The-Not-Busy-Line, 56.
Impulse Repeating, 26, 165.
Individual, 16, 146, 157.
Large Capacity, 14.
Level-Hunting, 57, 60, 134.
Local, 56.
Night Service Feature, 56.
Normals, 37, 94.
Regular, 56.
Release of, 38, 82, 108.
Repeating, 26, 166.
Rotary, 56, 106, 131.
Selector-Connector, 26, 150.
Small Capacity, 15,125, 128.
Straight Line, 56.
Switching Through, 26, 169.
Test, 61, 151.
Toll, 58, 141.
Toll & Local Regular, 59, 142.
Toll & Local, Trunk-Hunting, 60.
Toll Level-Hunting, 60.
Trunk-Hunting, Local, 56, 106, 131.
Trunk-Hunting, Local & Toll, 60.
Two-Ring, 64, 152.

Consecutive Number Service, 56.
Conversation Timing, 15, 161.
Cord Circuits, 70, 73.
Cordless Toll Board - See Automatic Toll Board.
Counter Cells, 21.
Counting Relays, 15, 81, 86, 130.
Crash Alarm, 174.
Crocker, 11.

## D

Delayed Ring, 59, 65.

DIAL, 1, 33, 81, 93.
3-Wire, 81.
Autodial, 34.
Back Equipment, 32D.
Circuit Connection of, 93.
Controlled Ringing, 15, 156.
Delayed Impulse, 33, 93.
Lettered, 3.
Locking, 33.
Metropolitian Use, 3.
Non-Returnable, 33.
Office Letters, 3.
Quieted, 34.
Returnable Type, 33.
Sanitary, 34.
Silent, 34.
Speed Range, 85.
Tele-Chec, 80, 85.
Thousand Year, 33.
Tone, 40, 102, 128.

DIALING METHODS, 179.
A. C., 11,
Composite, 11.
Loop, 11.
Simplex, 24.
Toll, 11,
Voice Frequency, 11.

Diehl, 22, 25.
Diezel, 180.
Digit Absorption -
Conference Call Switch, 177.
Reverting Call Switch, 161.
Selector, 46, 54.

Dimmer, 180.
Direct Line Service, 15, 16.

DIRECTOR, 9, 51, 177, 178.
In Havana, 10.
In Johannesburg, 10.
In London, 10.
In Venezuala, 177.

Discriminating -
Service, 16, 23, 32C, 169.
Tone, 12.

Distributer, Finder, 7, 40, 44. 45, 79.
Distributer, Test, 60, 71, 148.
Divided Ringing, 62, 63, 151, 157.
Dodge, 65.
Doyle, 33.
Drop Back Selector - See Digit Absorption.
Dry Trunk, Repeater, 179.

## E

Electrical Engineering - See Publications.
Elimination, Proscess Of, 2.
Eliminators, Battery, 22.
End Cells, 21.
Engh, 23.
Equipment Mounting, 32C.
Erickson, 3, 34, 36, 83.
Erlang, 25, 36.

EXECUTIVE -
Dial, See Autodial.
Key-Calling Service, 15.
Loudspeaking Direct Line System, 16.
Monitoring Service, 18.
Right-of-Way Service, 16, 107, 171.

## F

FINDER, 6, 38, 44.
10-Line, 126.
100-Line, 6, 39.
200-Line, 7, 41.
Circuit, 111.
Distributer, 7, 40, 44, 45.
Group Relays, 44, 45.
Mechanism, 44.
Preferential Hunting, 39, 41.

Finder-Connector Link, 6, 40.
Finder-Selector Link, 8.
Fire Alarm System, 16.
Fire Calls, 11.
Flash Busy, 58, 137.
Floor Plans, 16.
Frequency Selecting Connector, 63, 153.

## G

Generator, 37
Gould, 23, 67.
Grading, 9, 29, 49, 50.
Grand Rapids, 34.
Grandstaff, 11, 17, 24.
Grounded Line Adaptors, 31.
Group, Relays, 44, 45.
Grouping of Subscribers, 1, 34.

## H

Harmonic Ringing, 62, 151.
Herrmann, 16.
Hirch, 11.
Huffman, 177.
Humidity - See Air Conditioning.

## I

I. D. F., 32.
Impulse Repeater - See Repeater.
Intercept Service, 140.

IMPULSE -
Correcting - See Lock Pulsing.
Generators, 83.
Light & Heavy, 16, 85.
Lock Pulsing, 17, 85, 179.
Preliminary, 22.
Ratio, 83.
Repeating of, 84, 122.
Slugless Pulsing, 24.

Individual Connector, 16.
Individual Trunks, 9.
Information Service, 17.
Inspector's Trunks, 69.
Instantaneous Ring Cut-Off, 38, 107.
Intercepting Service, 17, 140.

INTER-CONNECTION -
Automatic To Manual, 53
Manual to Automatic, 53.

Inter-Locking Relays, 68.
Inter-Office Trunking, 9, 50, 55, 177.
Intercepting Service, 17.

## J

Jones, 177.

## K

Kahn, 180.
Keith, 1, 21, 27, 34, 36, 39, 49.
Keith, Erickson & Erickson, 1, 36.

KEITH (Plunger) LINE SWITCH, 27, 65.
2-Coil, 66.
3-Wire, 66.
Boards, 28.
Circuits, 95, 99.
Mechanism, 27, 66.
Self-Aligning, 67, 99.
Single Coil, 66.

Kessler, 23.

## L

Level- Hunting Connectors, 57, 60, 134.

LINE -
I. D. F., 32
Adaptors, 31.
And Trunk Standards, 17, 38.
Circuits, 94, 111.
Finder - See Finder.
Lock-Out, 15, 95, 158, 160.
Relays, 44, 94.

Line Switches, 27, 65. See also Keith (Plunger) Line Switches; Rotary Line Switches; and Secondary Line Switches.

LINK -
Finder-Connector, 6, 40, 126.
Finder-Selector, 8.
Timing, 15, 165.

Local Connectors, 56.
Local Switch Train, 10, 56.
Local Test Desk, 69.
Lock-Out, Line, 15, 95, 158.
Lock Pulsing, 17, 85, 165, 179.
Lomax, 48.
Long Line Adaptors, 31.
Loop Dialing, 11.
Loud Speaking Direct Line System, 16.

## M

M. D. F., 73.
M. I. T., 67.
Mc Elyea, 50.
Mc Meen & Miller, 9, 27.
Mahoney, 36.
Martin, 23, 38, 48, 66.
Master Switch, Circuit, 97.
Master Switch, Mechanism, 28.

MECHANISM -
B. P. O. Switch, 35, 36.
Finder, 44.
Keith Line Switch, 28, 66.
Master Switch, 28.
Minor Switch, 18.
Rotary Switch, 41, 177.
Strowger Switch, 3, 34, 180.

Mellinger, 33.
Message Registers, 17.
Metering, Booster Battery, 38.
Meters - See Message Registers; Traffic Meters.
Meyer, 65.
Microphonic Noise, 36.
Million Line System, 2.
Minor Switch, 15, 18, 130.
Mitchell, 50, 67.
Molina, 25, 26.
Molnar, 177, 180.
Monitoring Service, 18, 71.
Monophone, 33.

MULTIPLE -
Banks, 5, 9, 49.
Markings, 18.
Pen Recorder, 24, 25, 50, 58.
Slip In, 49.
Time Recorder, 26.

Murray, 50.

## N

Nelson, 51, 53, 178.
Newforth, 66.
Night Answering and Trunk Transfer Service, P.A.B.X., 21.
Night Service, 56, 133, 167.
Non-Numerical Switches, 5, 95.
Normals, 37, 94.
Number Assignment, 56, 95.

## O

Obergfell, 12, 33, 34.
Ostline, 12, 177.
Outgoing Secondary Line Switches, 19, 31, 51.

## P

P.A.B.X. (Privavate Automatic Branch Exchange), 20, 177.
Code Call, 12, 13, 165, 171, 173.
Connectors, 26, 165.
Direct Line Service, 15, 16.
Discriminating Service, 16, 169.
Fire Alarm System, 16.
Key Calling Service, 15.
Loud Speaking Direct Line System, 16.
Monitoring Service, 18.
Night Answering & Trunk Transfer, 21.
Passing Call Feature, 20.
Pick-Up Service, 21.
Purde University, 177.
Push Button Ringing, 22, 157.
Right-Of-Way Service, 16.
Special Services, 20.
Watchman's Service, 26, 167.

P.A.X. (Private Automatic Exchange), 20.
Code Call, 12, 13, 165, 171, 173.
Direct Line Service, 15, 16.
Fire Alarm System, 16.
Key Calling Service, 15.
Loud Speaking Direct Line System, 16.
Monitoring Service, 18.
Pick-Up Service, 21.
Push Button Ringing, 22.
Right-Of-Way Service, 16.
Special Services, 20.
Watchman's Service, 26, 167.

P.B.X. (Private Branch Exchange) -
Arcs, 57.
Connector, 56.
Supervision From, 57.

PARTY LINE SERVICE, 10, 62, 151.
Code Ringing, 64, 151, 161.
Divided Ringing, 62, 151, 153.
Harmonic Ringing, 62, 151.
Frequency Selecting Connector, 63, 153.
Reverting Calls, 63, 155, 157, 161.
Ten-Party, 65, 154.
Terminal Per Line, 63, 152.
Terminal Per Station, 62, 151.
Two-Party, 62, 63, 151.

Passing Call Feature, 20.
Pay Stations, 19.
Pen Recorder, Multiple, 24, 25, 50, 58.
Permanents, 71, 149.
Pick-Up Service, 21.
Plasmier, 177.
Plunger Line Switch - See Keith Line Switch.
Police Calls, 11.
Popple, 180.
Powell, 46.

POWER, 21.
Batter, 21.
Battery Eliminators, 22.

Preferential Hunting, 39, 41.
Preliminary Impulses, 22.
Prevention of Further Rotation, 37, 81.

PUBLICATIONS -
Automatic Electric Review (AER), 11, 33, 34, 50, 94.
Automatic Electric Technical Journal (AETJ), 177.
Automatic Telephone (AT), 3, 4, 8, 10, 11, 12, 14, 16, 17, 18, 19, 20, 21, 22, 23, 25, 27, 30, 33, 34, 38, 39, 48, 50, 55, 64, 65, 67, 81, 85, 94.
Bell Laboratories Record, 65.
Bell System Technical Journal, 50.
Strowger Technical Journal, (STJ), 10, 11, 12, 14, 17, 20, 23, 24, 45, 46, 50, 94.

Pulse Correcting - See Lock-Pulsing.
Pulses - See Impulses.
Purvis, 10.
Push Button Ringing, 22, 156, 157.
Pye, 45, 94.

Q

Quayle, 30.
Quieted Dial, 34.

R

R.C.X. (Remote Controlled Exchange), 23, 32D.
Rack Mounted Equipment, 32C.
Radio Interference, 23.
Ray, 48.
Register-Sender, 173.

RELAYS -
Counting, 15, 81, 86.
Delayed Operation & Release, 84.
Group, 44, 45.
Interlocking, 68, 86.
Line, 44, 94.
Pye, 45.
Two-Step, 95.

Release Link, 23.
Release of Connection, 38, 82, 108.
Remote Control Toll Board - See Automatic Toll Board.

REPEATER, 8, 46.
Adapters, 31.
Connector, 26, 166.
Circuits, 122, 124.
Dry-Trunk, 179.
One-Way, 47, 122.
Selector, 47.
Switching Selector, 47.
Two-Way, 47, 48, 124.

Restricted Service, 16, 23.
Reverse Battery Supervision, 38, 107.

REVERTING CALLS -
By Directory Number, 64, 155.
By Prefix to Directory Number, 64, 161.
By Special Number, 63, 157.

Richardson, 178.
Ricksher, 50.
Right-Of-Way Service, 16, 107, 171.

RING -
2-Ring, 151.
Back Tone, 38, 177.
Battery Connected Generator, 37.
Code, 64.
Code Selecting Conn. 65, 154, 164.
Cut-Off, 38, 107.
Delayed, 59, 65.
Dial Controlled, 15, 156.
Divided, 62, 63, 151, 157.
Draining Condenser Charge, 38.
Frequency Selecting Connector, 63, 153.
Ground Connected Generator, 37.
Harmonic, 62, 151.
Push Button, 22, 156, 157.
Re-Ring, 60, 139.
Splash Ring, 24.
Terminal Per Line Service, 63, 152.
Terminal Per Station Service, 62, 151.

Ringing Converter, 128.
Ringing Interrupter, 128.

ROTARY LINE SWITCH, 29, 67.
Circuit, 100.
Interlocking Relays, 68.
Mechanism, 41, 177.

Routiner, 23.
Ruggles, 39.
Rural Line Adapters, 31.

S

S.A.T.T. - See Automatic Toll Ticketing.
Salvesen, 14, 177, 190.
Saunders, 23, 25, 46, 48.
Sender-Register, 173.
Schwartz, 34.

SECONDARY LINE SWITCHES, 29, 68.
Outgoing, 19, 31, 51.
Pick-Up Circuit, 69.

SELECTOR, 7, 45.
3-Wire, 92.
10/20 Selector, 46.
Battery Searching, 45, 78, 102.
Circuit, 102.
Digit Absorbing, 46, 54.
Drop Back - See Digit Absorbing.
Incoming, 55, 32B.
Repeater, 47.
Repeater, Switching, 47.
Searching For Absence Of Ground, 45, 77.
Selector-Connector, 26.
Special 2nd, 22.
Stopping On First Idle Trunk, 45, 78, 103.
Toll Transmission, 58, 136.
Sender, 173.
Sequential Operation, 37, 45, 85, 92.
Service Meters - See Message Registers.
Service Observation, 23.
Side Switch, 37, 81, 92.
Sigo, 50, 58.
Silent Dial, 34.
Simplex, Dialing, 24.
Slip In Banks, 49.
Slip In Multiple, 49.
Slugless Pulsing, 24.
Smith, A. B., 11, 18, 20, 22, 177.
Smith & Campbell, 9, 34, 65, 94.
Soler, 55.
Sorber, 11.
Spark Suppression, 13, 105, 109, 121.
Special Services, 20.
Splash Ring, 24.
Station Equipment, 1, 33, 93.
Step-By-Step School, 50.
Strowger, A. B., 1, 27.
Strowger Bank, 4, 35, 180.
Strowger Mechanism, 3, 34, 180.
Strowger Technical Journal - See Publications.
Subscriber Station Equipment, 1, 33, 93.
Subscribers, Grouping, 1, 34,
System, 10-Line, 125.

SUPERVISION -
Answering, 38, 60, 107.
Reverse Battery, 38, 107.
From Manual Exchange, 57.
Toll Switch Train, 59.

Supervisory, Equipment, 24.

SWITCH TRAINS, 10, 55.
Local, 10, 56.
Test, 10, 56, 60, 147.
Toll, 10, 58, 136.
Verification, 10.

SWITCHES -
B.P.O., 35, 36, 45, 57.
Connector, 4, 36.
Minor, 15, 18.
Non-Numerical, 5, 95.
Rotary, 29, 67, 177.
Selector, 7, 45.

Switching Selector Repeater, 47.

T

3-WIRE -
Dial, 81, 92.
Line Switch, 66.
Strowger Switch, 3.
Selector, 92.

Tarte, 34, 38.
Tele-Chec System, 80, 85.
Telephone Instruments, Automatic, 33.
Temporator System, 80.
Terminal Assembly, 50.
Terminal Per Line, 63, 152.
Terminal Per Station, 62, 151.

TEST -
Connector, 61, 151.
Connector, Combination, 62.
Desk, Local, 69.
Distributer, 60, 71, 148.
Switch Train, 10, 56, 60, 147.

Tests, Wire Chief's, 75.
Time Recorder, Multiple, 26.
Time Service, 25.
Timing of Conversation, 15, 165.

TOLL -
Answering Supervision, 60.
Automatic Switching of Toll Lines, 11.
Automatic Toll Ticketing, 12.
Board, Automatic, 11.
Breakdown, 59.
Busy Test, 59, 61, 138.
Connector, 58, 141, 146.
Combination, Local, 58, 142
Combination, Trunk-Hunting 60.
Individual, 146.
Level-Hunting, 60.
Delayed Ring, 58.
Dialing, 11.
Disconnect, 59.
Offering Service, 59.
Re-Ring, 60, 139.
Supervision, 59.
Switch Train, 10, 58, 136.
Switching of Toll Lines, 11, 180.
Ticketing, Automatic, 12.
Transmission Selector, 58, 136.
Verification Service, 10, 61.

TONES, 25.
Busy, 37, 58, 59, 61, 107.
Class Of Service, 12.
Dial, 40, 102.
Discriminating, 12.
Ring Back, 38, 107.

Totalizing, 86.
Traffic Meters, 25.
Traffic Studies, 25.
Trafficorder, 177.

TRANSFER SERVICE -
Night Answering & Trunk Transfer, 21.
Passing Call Feature, 20.

Transmission Tests, 152.
Trunk-Hunting Connectors, 56, 60, 106, 131.
Trunk Termination, 32B.

TRUNKING -
Diagrams, 55.
Grading, 9, 29, 49, 50.
Inter-Office, 9, 50, 177.
Secondary Line Switch, 30.
Within the Office, 8, 32D, 49, 180.

TRUNKS -
Common, 9.
Dry, 179.
Graded, 9, 29, 49.
Individual, 9.
Inspector's, 69.
Termination Of, 32B.
Two-Way, 47.

U

Universal Numbering, 32C, 54.

V

Verification Service, 61, 150.
Verification Switch Train, 10.
Voice Frequency Dialing, 11.
Voltage Control, 21.
Voss, 11.

W

Wagner, 34.
Walker, 20, 50, 64.
Watchman's Service, 26, 167.
Wicks, 11, 17.
Wilkinson, 50.
Wire Chief's Test Desk, 69.

# STROWGER PROGRESS

## *History and Development of the Strowger Automatic Telephone System*

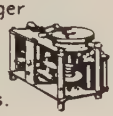
**1889** Almon B. Strowger invents switch having line contacts in circular rows inside a cylinder. Controlled by push buttons on telephone.



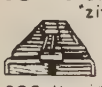
**1891** Invention of 1000 line switch with disc bank having ten concentric rows of line contacts. Not used commercially. Formation of Strowger Automatic Telephone Exchange



**1892** First commercial Strowger installation, La Porte, Ind. Used switches with 100-line disc type banks.



**1894** Invention of gear-driven switch with "zither" (piano wire) line banks. Not used commercially.



200 line "zither" board with ratchet drive installed at La Porte, Ind.

**1895** Third installation at La Porte. Earliest use of switch with semi-cylindrical bank and shaft with vertical and rotary motions. Invention of earliest dial type calling device

**1896** Invention of selector trunking; first use of dial telephones in large exchange. (Augusta, Ga.)



**1898** Earliest use of relays for switch control, instead of direct operation of magnets, over line wires. First die cast switch frame.

**1899** Strowger Automatic goes abroad (Berlin, Germany). Earliest use of automatic trunk selection, with busy test.



**1900** Basic trunking principles established for large exchanges-used at New Bedford, Mass. Bank terminals molded in plaster of paris.

**1901** Formation of Automatic Electric Company to take over Strowger Automatic Telephone Exchange. Installation at Fall River, Mass., used line banks with fiber insulators and aluminum fillers. First use of "slip multiple."



**1902** First installation in Chicago begun. Earliest use of measured service in automatic exchanges

**1903** Large Strowger installations placed in service in Grand Rapids, Dayton, Akron, Columbus.



**1904** First use of multi-office trunking, and connections between automatic and manual offices. (Los Angeles, Cal.)



**1905** Earliest extended use of party lines and reverting calls First system using common battery talking. (South Bend, Ind.)



**1906** Invention of Keith Line Switch, resulting in enormous reduction in cost of automatic boards. First used at Wilmington, Del.



**1907** First installation in Canada (Edmonton, Alta.) Invention of small dial and two-wire system eliminating ground at subscriber's station.

**1908** First two-wire system (large dial) installed at Pontiac, Ill. Earliest use of automatic, intermittent ringing. Installation at Lansing, Mich., features use of small dial, secondary line switch, and 200-pt. selectors and connectors.



**1909** Invention of outgoing secondary line switch, resulting in economy of inter-office trunks. First used at San Francisco.

**1910** Strowger system introduced in Hawaii and Cuba. Earliest use of dialing over toll lines. Introduction of revertive ringing tone.



**1911** Formation of Automatic Telephone Manufacturing Co., Ltd., for production of Strowger system in England.

**1912** First Strowger installation in England. (Epsom "Official Switch")

**1913** Strowger system introduced in Australia and New Zealand. Development of key type impulse sender, and Simplex dialing on toll lines.




**1914** Automatic Switches used as traffic distributors in manual exchanges. (Indianapolis and Defiance, Ohio)

**1915** Development of modern covered switch with horizontal relays – used at St. Paul and Minneapolis. First use of cast iron switch frame at Hazelton, Pa.



**1916** Earliest community automatic exchange network, installed in Wisconsin.



**1917** Rapid expansion in the use of private automatic branch exchanges. Development of remote alarm equipment for unattended exchanges.

**1918** First installation using rotary primary line switches. (Elyria, Ohio)



**1919** First Strowger board manufactured for Bell system. (Norfolk, Va.)

**1920** Beginning of widespread adoption of Strowger equipment for metropolitan areas both in U.S. and abroad. First installation of call-indicator equipment for automatic-manual connections in multi-office areas.



**1922** Introduction of improved steel wall telephones and improved desk stands (Type 21)



**1923** British Post Office announces adoption of Strowger system (with Director) for London.

**1924** Strowger exchanges installed throughout Canal Zone. First Strowger "Directors" installed at Havana.



**1925** Introduction of the Monophone – first hand set telephone of modern type.



**1926** Introduction of the Type 24 Dial – modern, quiet-running, long life calling device. Strowger system adopted by Japan.



**1927** First "Director" installation in London. Introduction of line switch with self-aligning plunger.



**1928** First extended use of Strowger 200-point Line Finder. Introduction of improved Monophone designs.



**1929** U.S. Navy begins use of Strowger equipment. Monophones made available in color.



**1930** Development of new small switchboards of unit type. Networks of small Strowger exchanges installed in Italy



**1931** Development of Strowger Remote Toll Board First installed at Elyria, Ohio.



**1932** Development of unattended private automatic branch exchanges. Two line Monophones introduced.



**1933** New small private automatic exchanges introduced.



**1934** Introduction of new self-contained desk Monophone molded in bakelite. (Type 34A3)



**1935** New "all-positions" transmitter. New bakelite wall Monophone (Type 35A5)



**1936** Small, compact community automatic exchanges introduced.



# AUTOMATIC TELEPHONE PRACTICE

## INTRODUCTION AND ELEMENTARY PRINCIPLES

ithin a few years after the invention of the tele-
one numerous patents were issued for devices
nich were intended to take the place of operators in
setting up" telephone connections. The first suc-
ssful system was based on a switching mechanism
vented by A.B. Strowger in 1889.

e characteristic feature of machine switching sys-
ms is the method adopted in "setting up" con-
ctions so that telephone conversations can take
ace. The manual and machine switching systems
th aim at the same ultimate result, which is to
entify all subscribers by means of a numerical sys-
m, and to be able to place any two of them in com-
unication over a pair of wires. The distinction is
e of means. The manual system employs oper-
ors, the machine switching systems employ elec-
ically operated mechanisms. This text will deal
th the principles of Strowger Automatic, referred
by the Bell System as "Machine Switching Step-by-
ep Method."

art A has been prepared for those readers who
ust start from scratch. Each step appears in logi-
l sequence, and requires the reader to know only
at which has gone before. No previous education or
perience along telephone lines is required.

eaders of more mature years, already having some
owledge of the telephone business, may find it ad-
sable, immediately after completing a given section
Part A, to read the corresponding section in Part
. This may be pretty hard going, as Part B pre-
pposes a working knowledge of Strowger Automatic
ould the reader find difficulty in mastering any
ction, he may find it helpful to skip it and go to the
xt. The obscure section will usually become clear
he proceeds, or when he goes back to it later.

00. Subscriber Station Equipment: Just as in a
anual system, a Strowger Automatic exchange may
divided into subscribers station equipment, cen-
al office, and wire plant. A telephone used in a
rowger Automatic exchange comprises the con-
ntional ringer, circuit switching device, receiver, transmitter, etc., and in addition thereto a calling device termed a "dial". By means of this dial the Strowger Automatic switches in the central office are controlled for the purpose of setting up a connection to the desired telephone line.

101. The Dial: A dial type calling device, for use with the Strowger System, was patented by Keith, Erickson and Erickson in 1898, the principal claim reading: "The combination of a movable device having a series of adjacent finger-holds, a circuit breaker actuated on movement of the device to send a number of impulses corresponding to the selected holds and a single stop arranged to contact with the finger in the finger-holds and limit the movement thereof, substantialy as set forth."

For the purpose of this section it will suffice to say that the dial enables the calling party to control the Strowger Automatic switching mechanisms which establish the telephone connection.

102. Grouping of Subscribers: To describe the process of matching, which underlies counting (and incidentally the selection of a desired unit in the class which has been counted), the mathematicians use a picturesque name. They call it putting classes into a "one-to-one reciprocal correspondence."

A group of telephones, irrespective of its size, may be matched in one-to-one correspondence with the integers, or natural numbers. This matching having been accomplished, each telephone is tagged with an identifying symbol, which, when "spelled out" on the dial, will cause the Strowger Automatic switches to extend the calling line a step at a time until it finally reaches and connects with the called line.

Probably few readers of this section will ever have occasion to lay out a million line system. The writer is a bit apologetic for taking up the readers time with such an involved subject at the start of the text, but feels that a familiarity with the theory involved will make for a better understanding of the sections to follow.

102 (a). Referring to Fig. 1, let us assume that the area inclosed within the heavy triangle represents one million telephones, each telephone being identified by a six-figured number, e.g. 76 3458. It will be seen that this area has been divided into ten districts and each district given a number. The call numbers have been assigned in such a way that all telephone numbers having the same first digit have been placed together, e.g. all telephones numbered from 50 0000 to 59 9999 have been placed in district No. 5. Each district therefore accommodates 100,000 telephones.

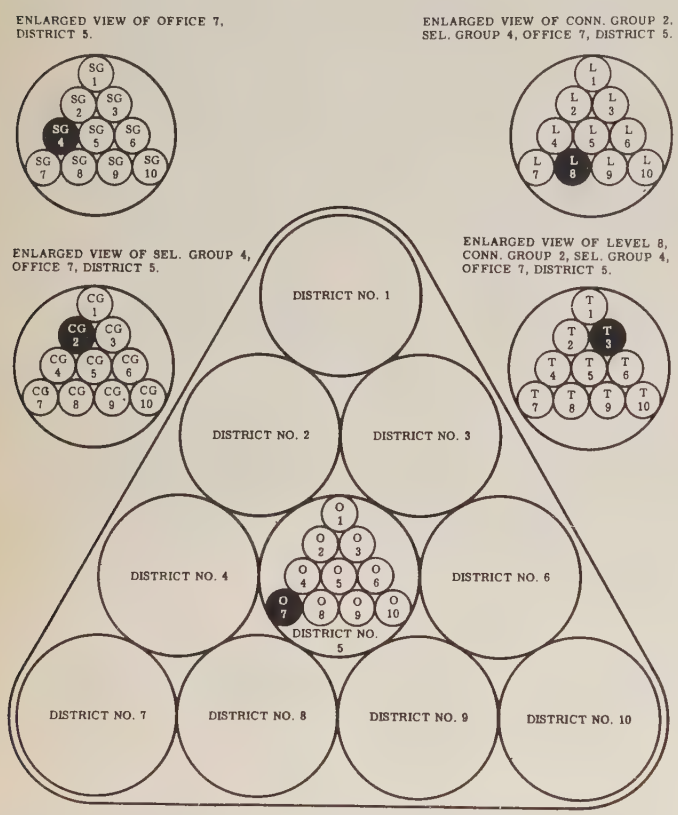



Fig. 1 - Theoretic Million Line System.

Each district has in turn been divided into ten offices, as shown in "district No. 5." The call numbers within the district have been assigned in such a way that all telephone numbers having the same second digit have been placed together, e.g. all telephones numbered from 57 0000 to 57 9999 have been placed in office 7, district No. 5. Each office therefore accommodates 10,000 telephones.

Each office, in each district, has in turn been divided into ten selector groups, as shown in "office 7, district No. 5." (Enlarged view.) The call numbers within the office have been assigned in such a way that all telephone numbers having the same third digit have been placed together, e.g. all telephones numbered from 57 4000 to 57 4999 have been placed in selector group 4, office 7, district No. 5. Each selector group therefore accommodates 1,000 telephones.

Each selector group in each office, has in turn been divided into ten connector groups, as shown in "selector group 4, office 7, district No. 5." (Enlarged view.) The call numbers within the selector group have been assigned in such a way that all telephone numbers having the same fourth digit have been placed together, e.g. all telephones numbered from 57 4200 to 57 4299 have been placed in connector group 2, selector group 4, office 7, district No. 5. Each connector group therefore accommodates 100 telephones.

Each connector group, in each selector group, has in turn been divided into ten levels as shown in "connector group 2, selector group 4, office 7, district No. 5." (Enlarged view). The call numbers within the connector group have been assigned in such a way that all telephone numbers having the same fifth digit have been placed on the same level, e.g. all telephones numbered from 57 4280 to 57 4289 have been placed in level 8, connector group 2, selector group 4, office 7, district No. 5. Each level therefore accommodates 10 telephones.

Each level, in each connector group, has in turn been divided into ten telephone lines, as shown in "level 8 connector group 2, selector group 4, office 7, district No. 5." (Enlarged view.) The call numbers within the level have been assigned in such a way that telephones number 57 4281, 57 4282, 57 4283 58 4284, 57 4285, 57 4286, 57 4287, 57 4288, 57 4289, and 57 4280 appear in level 8, connector group 2 selector group 4, office 7, district No. 5.

102 (b). Process of Elimination: Thus it will be seen that any individual telephone in a million line system can be reached by a process of elimination. Should telephone number 87 6543 be desired, we first go to district No. 8, which eliminates all telephones (900,000 in number) in the other districts, and at the same time limits us to the 100,000 numbers in district No. 8.

We must next go to office 7, which eliminates all telephones (90,000 in number) in the other offices of this district, and at the same time limits us to the 10,000 numbers in office 7.

We next go to selector group 6, which eliminates all telephones (9,000 in number) in the other selector groups of this office, and at the same time limits us to the 1,000 numbers in selector group 6.

We next go to connector group 5, which eliminates all telephones (900 in number) in the other connector groups of this selector group, and at the same time limits us to the 100 numbers in connector group 5.

We next go to level 4, which eliminates all telephones (90 in number) in the other levels of this connector group, and at the same time limits us to the 10 numbers in level 4.

We finally go to telephone 3, which eliminates the other telephones in this level, i.e. telephones numbered 87 6541, 87 6542, 87 6544, 87 6545, 87 6546 87 6547, 87 6548, 87 6549 and 87 6540.

2 (c). For further discussion of a "Million Number System" see AT (Campbell) 1-20.

2 (d). In the early days of Strowger Automatic it as realized that a four digit number was about the ost that a subscriber could carry in his head, so e telephone offices were designated by single letrs. See the dial in Fig. 2. The manual opposition







ig. 2 - Dial With Office Letters. Fig. 3 - Dial For Metropolitan Use.

mediately cried to high heaven that the public did ot have intelligence enough to dial one letter followed by four digits.

he literacy of the dear public must have greatly improved in the last twenty years. Now they are expected to dial the first three letters of an exchange ame, disregard the remaining letters, and then dial e required four digits. See the dial in Fig. 3. Very it maketh a difference whose ox is being gored.

ee AT (Brown) 5-24 for photographs and discussion "dial cards" similar to the one shown in Fig. 2.

02 (e). Smaller Systems: Working backwards thru ig. 1, the reader will note that a 100-line office requires only a single connector group; a 1000-line office requires one selector group, having within it ten onnector groups; and that a 10,000-line office is ade up of ten selector groups, each comprising ten onnector groups.

03. Strowger Mechanism: Switch mechanisms are he "mechanical operators" which serve to perform ll the switching functions of a telephone central ffice. The Strowger mechanism serves equally well s a connector, finder, or selector, with but minor ariations in its electrical circuits and mechanical omponents.

The Strowger mechanism is an electro-mechanical evice capable of imparting the following movements o a wiper-carrying shaft: (1) the shaft may be raised ertically any number of steps from one to ten, then (2) the shaft may "rotated in" any number of steps from one to ten, after which, (3) the shaft may "release" to its normal position by first rotating backward under the influence of a spring, and then falling by gravity.

This "up, around, and return" movement is the distinguishing characteristic of the Strowger mechanism as manufactured in America. For a discussion of the English version, see Section 203 (a).

Figure 4 is an old patent drawing made by Burfiend, and well illustrates the Strowger Mechanism.

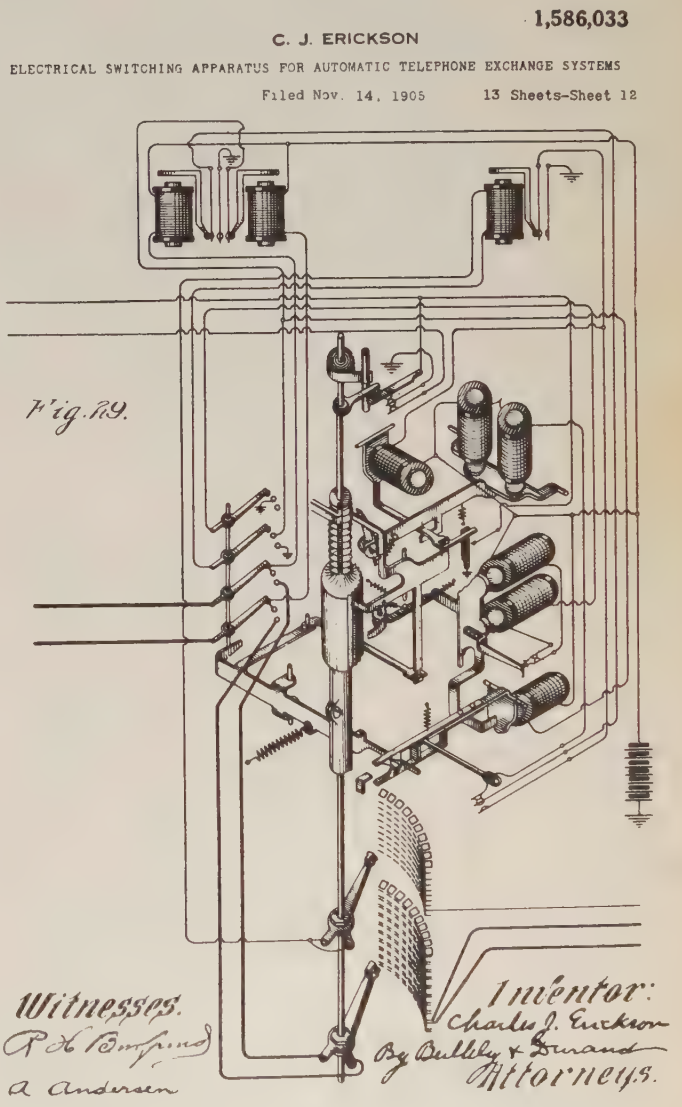



Fig. 4 - Strowger Switch Mechanism. This old patent drawing well illustrates the Strowger switch mechanism, although it shows some parts that are not used on modern switches, it is shown here because of its historic interest.

See AT 2-22 for article on development of the Strowger Switch Mechanism.

104. Strowger Bank: The nomenclature relating to Strowger equipment is in a state of utter confusion, and that having to do with the bank is probably the most hopeless of all. In this section the term "point" will be used to mean "objective."

In the previous section it was shown that the Strowger wiper could be moved vertically from one to ten steps, each vertical step representing a "level" over which the wiper could then be rotated any number of steps from one to ten. In Fig. 1 are shown the one




Fig. 1 - Connector Bank Numbering.

hundred objectives which comprise the Strowger bank, each being designated by the number of vertical and rotary steps necessary to reach that particular location. Note that "0" represents 10, just as it does on the dial.

Relays can be associated with the Strowger mechanism in either of two principal ways, producing two different results. In one case, the mechanism is self-actuated. The wiper in moving up and around searches for and finds an objective which represents a calling circuit. Such a switch is known as a line finder. In the other case, the mechanism is actuated by impulses from an external source, the wiper being driven up and around to reach an objective representing a called circuit. The switch is then known as a connector.

The mechanism and the bank are the same in both cases. The distinction to keep in mind is that the line finder is self-actuated to reach its objective, while the connector is actuated by impulses externally generated as from the calling subscriber's dial.

Irrespective of what you may have learned in the past, always remember that the Strowger switch mechanism has access to a 100-point bank (or banks). In this way, and in this way only, can any desired objective, out of a class of one hundred such objectives, be reached by taking a maximum of twenty uniform steps.

For article on the development of the Strowger bank see AT (Clapham) 4-20.

105. Strowger Connector: A single Strowger connector will first be discussed, then a group of connectors and finally a finder-connector link. Assume that each point within the Strowger bank shown in Fig. 2 is connected to a telephone (two such telephones are shown for illustration). At the lower left hand corner of the connector bank is shown a pair of "wipers" connected to a "calling telephone."

Imagine the wipers stepping up to any level, then rotating in, and finally coming to rest on a point in that level. Actually, the wipers are so moved under the control of the dial on the calling telephone. For instance, suppose that the calling telephone desires to call telephone 32. Dialing the digit "3" causes the wipers to be raised to the third level. Dialing the digit "2" will now cause the wipers to rotate two steps in on the third level, thus bringing the calling telephone into connection with telephone 32.

Notice the straightforward "decimal" principle of the above scheme. There are 10 horizontal levels and 10 points on each level. Thus, the tens digit of the called number represents the level, while the units digit represents a particular point in the level. Numbers beginning with 1 are in the first or bottom level; numbers beginning with 2 are in the second level, etc. This causes the digit "0" to be used to represent ten steps, so that the tenth or top level is

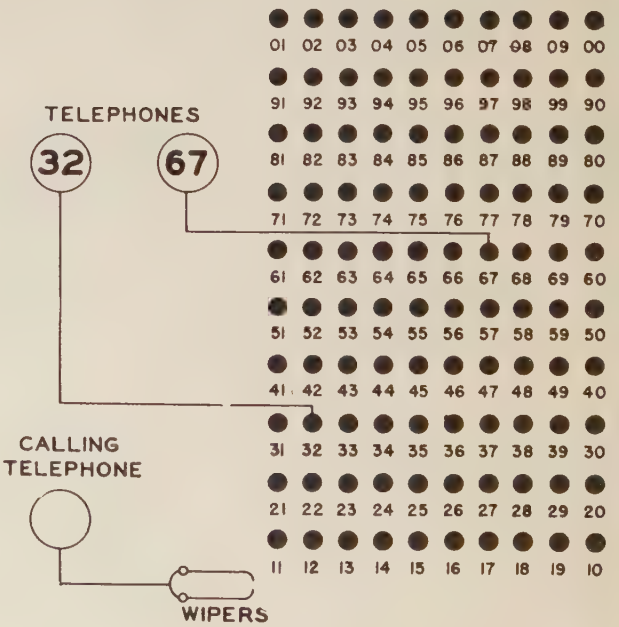



Fig. 2 - Connector Bank and Associated Telephones.

indicated by the symbol for "zero." Also, the tenth point in each level is indicated by the symbol for "zero."

eferring again to Fig. 2, note that the "calling tele-
one" can connect with any one of the 100 tele-
ones,but that there is no provision for the 100 tele-
ones to connect with each other. Such a scheme, in
hich only one telephone could originate calls, would
e very impractical.

ow consider Fig. 3. Here each telephone is shown
nnected not only to the wipers of its own connector,
t also to its proper point in each connector bank.
he wipers of each connector stand ready to be
epped up and around under control of the associ-
ed telephone's dial. It may now be pointed out that
e bank with its wipers, plus the mechanism re-

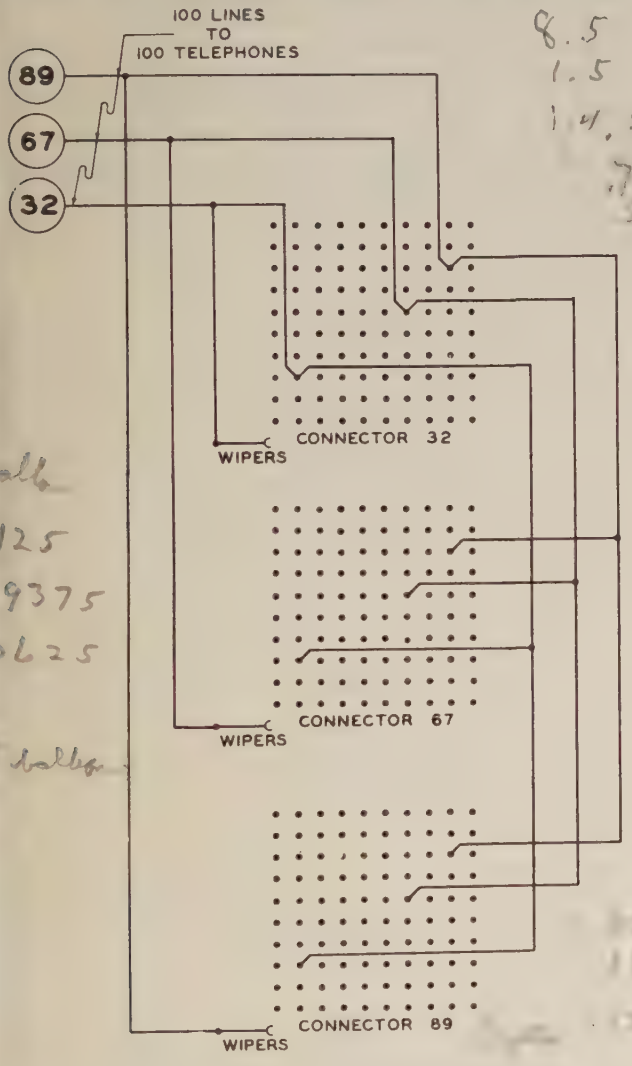



Fig. 3 Connector Banks in Multiple.

uired to step the wipers up and around, constitutes a
connector switch." It is interesting to note that a
nnector is referred to as a "numerical" type of
witch because it operates under control of the dial.

n practice, the connector and other switches to be
escribed later actually have two or more banks
with associated wipers) fitted to the same switch.
owever, the extra banks are for control and special
eature purposes and need not be considered for an
nderstanding of the principles of telephone switch-
ng.

In Fig. 3, only three of the 100 telephones, with their associated connector switches, are shown for illustrating the principles involved. The diagram is simplified by showing only one wire from each telephone, and a circle at each of the 100 points in each bank. Actually, each circle represents one contact, two contacts, or as many contacts as are necessary to complete the circuit.

Telephone 32 is connected to the wipers of connector 32. Telephone 32 also has an "appearance" in the bank of each connector, that is, it is multipled to point 32 in all of the connector banks. Telephone 67 terminates in the wiper of connector 67 and is likewise multipled to its associated point, 67 in all of the connector banks. It is this multiple arrangement of the connector banks which permits any telephone to call any other telephone in the system.

To take an example, if telephone 32 desires to connect with telephone 89, the procedure is merely to lift the handset from the cradle at telephone 32, and dial the digit 8 and 9. Dialing 8 causes the wipers of connector switch 32 to step up to the eight level; dialing 9 causes the wipers to rotate into the bank and come to rest on the ninth point of that level. This completes the connection to telephone 89. In a similar manner, dialing from any one of the 100 telephones will cause the wipers of its particular connector switch to step up and in and connect with any one of the other 99 telephones.

Notice that the 100-line connector system just described requires an individual connector switch for each line in the system. Since a connector is a rather expensive switch, this scheme would be very uneconimical because the average telephone is used for making calls only a short time each day and the corresponding connector switch would remain idle the rest of the time. We shall see in the following sections how the line finding principle permits a large group of lines to be served by a much smaller number of switches used in common by all lines in the group.

106 Non-Numerical Switches: In earlier Strowger systems, individual line connectors were used for systems of 100 lines or less. The time efficiency of the subscribers telephone line, and likewise, the switching equipment associated therewith is very low; therefore, it is more economical, both from a viewpoint of initial cost and maintenance, to provide individual line equipment of more simple design and few functions. In modern Strowger systems, this equipment takes the form: (1) of a non-numerical switching device associated with each subscribers line (lineswitch see Sec. 177), or (2) a non-numerical switching device associated with each connector and capable of finding any line in the group (line finder, see following sub-section).

106 (a). Strowger Line Finder: The line finding principle is presented by means of a simplified diagram in Fig. 1. Two 100-point banks are shown, one being called "finder bank" while the other is the now familiar connector switch bank. The finder bank is similar to the connector bank, and although only one telephone is shown in the figure, let us imagine that there are 100 telephones connected to the finder bank. Also, it is pointed out that the finder bank has associated with it a pair of wipers and the mechanism required to step the wipers up and around, the entire assembly constituting a "line finder" or, more simply, a "finder."

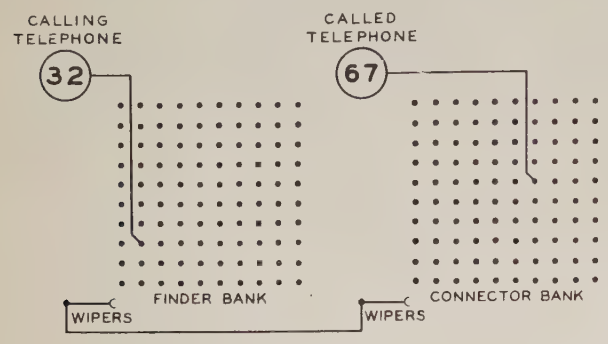



Fig. 1 - Finder-Connector Link.

The operation is as follows: A person desiring to make a call removes the handset from the cradle; the finder automatically steps its wipers up and in and "finds" the calling line. In Fig. 1, the finder would step its wipers up to the third level and around two steps, stopping on point 32. The calling telephone is thus extended through to the wipers of the connector switch. When the digits 6 and 7 are dialed, the connector switch wipers step up six steps and around seven, completing the connection between telephones 32 and 67.

Line finder action may be likened to that of a manual operator inserting an answering plug into a line jack.

A line finder is sometimes referred to as a "non-numerical" type of switch since its operation is automatic and not under the control of the calling person. This is in contrast to a connector switch which follows dial impulses.

It is obvious that if only one finder switch and one connector switch were furnished, only one conversation would be possible at any one time, since each conversation requires one finder and one connector to complete and hold a connection between the calling and the called telephones. The next section describes how several simultaneous calls are made possible.

107. Finder-Connector Link: Consider now Fig. 2, which shows several finders and connectors. Notice that each finder switch is permanently tied "tail-to-tail" with a connector switch; that is, the finder is looking backward ready to find any line desiring to make a call, and the connector is facing forward ready to connect to the dialed line. Such a combination of finder and connector is called a "finder-connector link." It is obvious that one such link is required for each of the conversations which are to be held simultaneously. The links may be compared to the "cord circuits" in a manual telephone system.

Inasmuch as each of the 100 lines has an appearance in each finder bank, any idle finder would be capable of stepping up and around to locate any one of the 100 lines which desires to make a call. Furthermore, since each of the 100 lines also has an appearance in each connector bank, the connector tied to the above finder, can step in and around (under control of dial impulses from the calling telephone) to complete a connection with any one of the 100 telephones. The leads from the connector banks back to the 100 telephone lines are called "line normals."

To trace a call, let us assume that telephone 32 desires to call telephone 89. Upon the removal of the

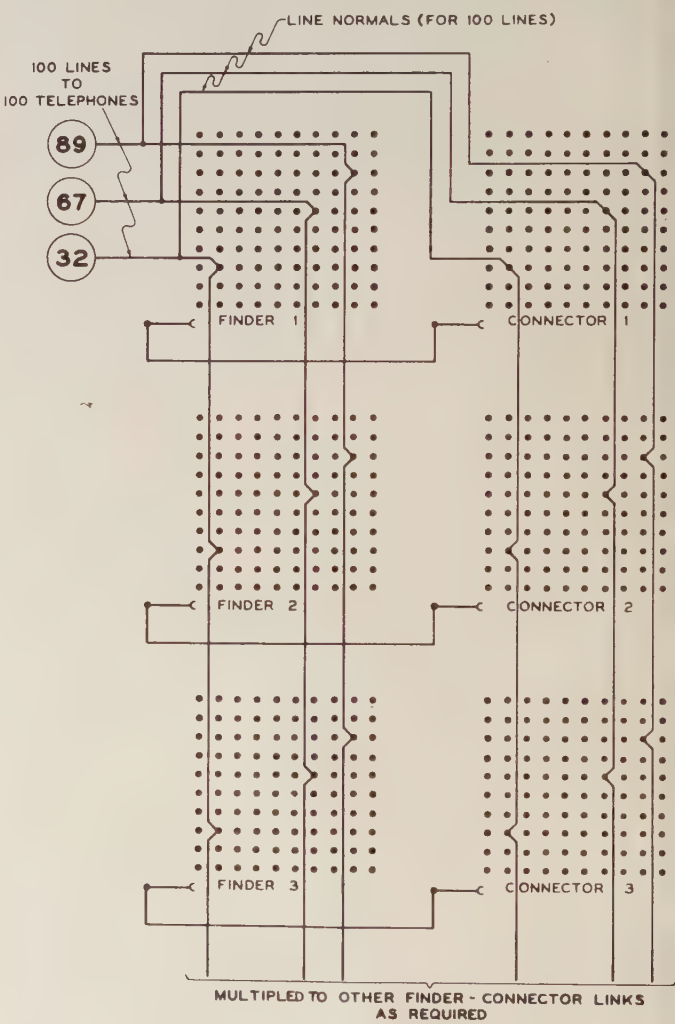



Fig. 2 - Finder Banks in Multiple; Connector Banks in Multiple.

handset from the cradle at telephone 32, an idle finder will step up and around and come to rest on point 32. The connection is now extended through to the connector associated with the finder. When the digits 8 and 9 are dialed, the connector switch wipers

l step up and around and come to rest on point 89. e connection is now completed from telephone 32, ough the finder-connector link, and back over the e normal to telephone 89.

3 Finder Distributor: It is apparent that some ans must be provided for assigning idle finders to arch for calling lines and for telling the assigned der when to start and where to stop. Figure 3

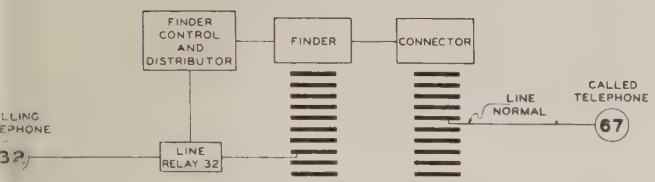



Fig. 3 - Complete Finder-Connector System.

ows a complete finder-connector system (100-line apacity). The symbols for the finder and connector ave both been simplified, the banks being illustra- d merely by ten horizontal lines; the rectangle at op represents the switch mechanism. There is one line equipment" associated with each line, while ne "finder control and distributor" equipment is ommon to all lines. Only one finder-connector link s shown; however, it is to be understood that there re many such links.

A call through the complete finder-connector system rogresses as follows: When the handset is removed rom the cradle at calling telephone 32 the associated ine equipment (1) "marks" the position of line 32 in ll the finder banks, and (2) sends a "start" signal to he finder control and distributor equipment which causes a preselected finder to start searching for calling line 32 (the finder control and distributor equipment at this time preselects the next idle find- er); the finder searching for line 32 finds it and ex- tends the connection through to the associated con- nector switch, which completes the connection in ac- cordance with the digits dialed.

109. The 200-Line Finder: The finder so far discussed has been capable of serving only one hundred lines. Under certain conditions there is an economic advantage in using banks of large capacity. Generally speaking, the greatest economic value is obtained when the proper ratio is maintained between bank cost and switch cost. However, a high bank cost may sometimes be justified if it will result in eliminating an entire "rank" of switches. For example, a 1500 line system using 200-line connectors can be handled with first selectors and connectors, while if 100-line connectors were used, first selectors, second selectors and connectors would be necessary. Of course, the probabilities of growth beyond 2000 lines must be considered also.

For the above reason, a finder has been developed which will serve a total of two hundred lines.

The mechanics of this switch are the same as that of the 100-line finder, the difference being that the wipers have access to two 200-contact "line banks" and one 200-contact "private bank." If the switch is moved up and in "XX" steps, one set of wipers will be standing on the bank contacts of the "XX" line in the odd hundred group, while the other set of wipers will be standing on the "XX" line in the even hundred group. The problem then is to select one or the other set of wipers.

110 Strowger Selector: In our previous discussion, we have considered no numerical switch except the connector, and have thereby limited the size of our exchange to one hundred lines. We will now take up the study of a one thousand line system, the one thousand lines being divided into ten groups of one hundred lines each. Each group will be served by ten connectors whose banks are in multiple, each connector having access to all the lines in its group. If we wish to call telephone number 563, it is first necessary that we obtain access to one of the connectors serving the 500 group, after which we will dial 63 and complete the connection in the usual manner. It makes no difference to us which one of the ten connectors we use, as all of them have access to line number 63.

In order to obtain access to a connector serving the proper group, we must supply a new piece of apparatus called a selector. The mechanical structure of a selector is similar to that of a finder or a connector. It has the same familiar bank, wipers, and mechanism to step the wipers up and in. The selector faces forward toward the called line as does the connector.

Notice in Fig. 1 that the lines are divided into groups of 100, two such groups being shown, namely, 100 lines in the "200" group, and 100 lines in the "600" group. For each group, there is a corresponding

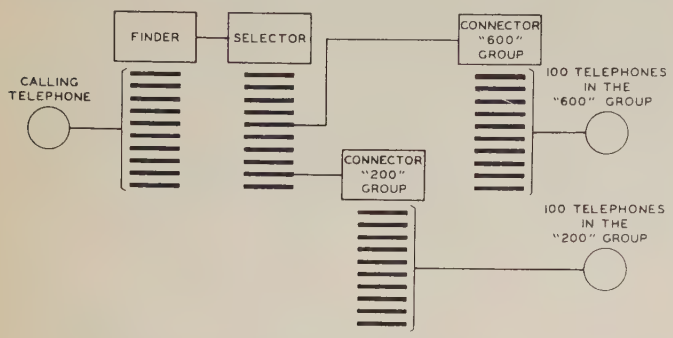



Fig. 1 - Basic Selector System.

group of connectors having their banks multipled together. As usual, only one connector from each group is shown. Each connector has access to all lines in its own group.

To illustrate the operation we will assume that the calling telephone in Fig. 1 desires to call telephone 673. Upon the removal of the handset, an idle finder searches for and extends the calling line to the selector switch associated with that particular finder. The calling subscriber then dials the hundreds digit 6. This causes the selector to step its wipers up to the 6th level, whereupon it automatically rotates its wipers in on that level in search of a point to which is attached an idle connector switch serving the "600" group. The leads to the connectors are called "trunks" and the automatic selection of an idle trunk is called "trunk-hunting" (see Fig. 2.)

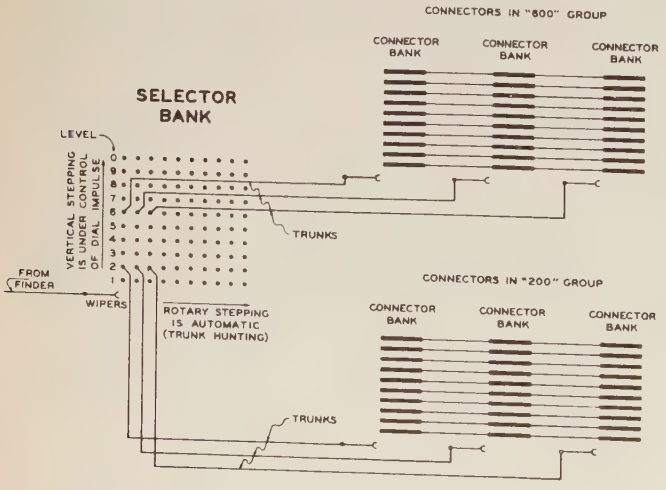



Fig. 2 - Trunks Leading From Selector Banks To Connectors.

It is interesting to note here that a selector switch is capable of searching over the ten points, on the dialed level, quicker than a calling person can dial the next digit, even if that digit is a "1", see Sec. 201 (c).

Assuming that the selector finds an idle trunk, the call is extended through to a connector. When the subscriber dials the digits 7 and 3, the connector is stepped up and around and the call is completed in the usual manner.

As shown in Fig. 1, in a selector system each finder switch is tied "tail-to-tail" with a selector switch instead of to a connector switch as in the 100-line capacity system. Here again, enough finder-selector links are required for the greatest number of conversations which are likely to be held simultaneously in that group. The connector switch always comes last and selects the "tens" group of lines and the "units" line within the group.

111. The Impulse Repeater: The impulse repeater is used in conjunction with Strowger telephone systems serving exchange areas of more than one central office. A repeater is required for each central-office trunk-line used for outgoing service to another office. The functions of the repeater are such that it needs no mechanical switching mechanism as the Strowger switch does; it consists usually of a group of relays. Each repeater, is a fixed component of an inter-office trunk-line. Consequently, any given repeater is associated with only one distant central office, is located in the office in which the trunk call originates, and is directly connected, by means of the trunk line, to an incoming switch (selector or connector) in the distant office.

112 Trunking Within the Office: The components of a simple system having been discussed, we now enter upon a really difficult subject-trunking. Trunking is tough, and anyone who doubts it might try reading the first chapter of Smith & Campbell.

In AT (Clapham) 8-20 it was said, "while the mechanical and electrical design of Strowger equipment is highly standardized and the interior wiring quite permanent, it is also true that the trunk connections between switch groups are remarkably flexible and changes in trunk distribution may be made with very little expenditure of time and effort. This is made possible by a methodical arrangement of the terminals of the selector switch bank multiple cables." While he may have been a little optomistic in regard to circuit-standardization, he was very right as to the flexibility of trunk distribution.

This text will approach trunking in a very unorthodox manner, which probably will irk specialists in that field. However, there is a chance that it may be understood, and if the reader gets even some faint glimpse of understanding - that is all we can hope for.

In order that we may have a firm basis on which to start, let us assume that the initial number assignments within the 800 connector group have been "evenly distributed so that the traffic load can be handled in accordance with the facilities provided." (A.E.Co.Bul. 512.) We will further assume that, by calculation of switch quantities (A.E.Co. Bul. 2011), it has been determined that the busy hour traffic into this group of lines can be carried by 10 connectors. So much for the moment; we will now go into something else.

electors are arranged in groups of ten, which are rmed "shelves," and are designated by the letters , B, C, etc. The banks of the switches which are in ie same shelf are multipled together and, from the ist switch in the shelf, the outgoing trunks are ired to a terminal strip.

eferring to Fig. 3, let the four single contact rows A, 2A, 3A, and 10A represent the eighth level in the en selectors on shelf A. In the same way the four ingle contact rows 1B, 2B, 3B, and 10B, represent he eighth level in the ten selectors in shelf B.

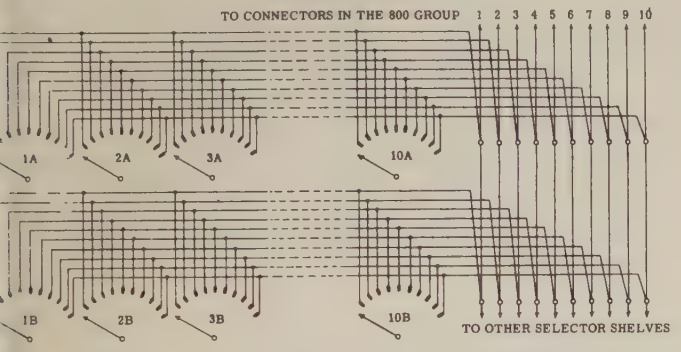



Fig. 3 - Trunks Multipled Through a Plurality of Selector Shelves. Note "straight" multiple of banks and terminals.

It will be noted that the contacts in the level are multipled "straight," as are the terminal strips. Just above the terminal assembly is the designation, "To connectors in the 800 group," and just below the terminal assembly is the designation, "To other selector shelves."

So long as the traffic into the 800 connector group can be handled by ten trunks it matters not how many selector shelves are connected in multiple.

112 (a) Grading: Grading is a six-bit word which is now used to describe the use of "individual and common trunks." The idea is old, and was fully discussed in Smith & Campbell.

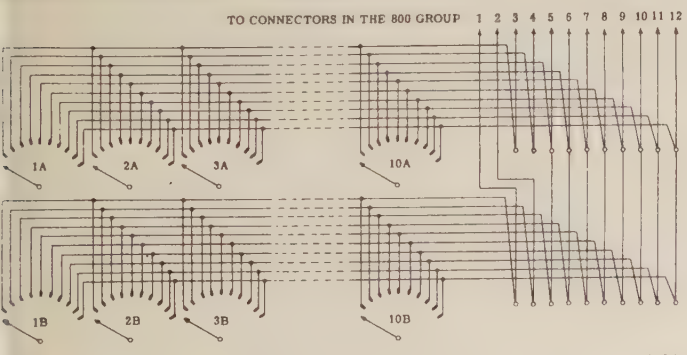



Fig. 4 - Illustration of Grading. Two individual trunks per shelf, and eight trunks common to the two shelves.

Suppose the traffic into our 800 connector group requires more than 10 connectors; the answer is to assign one or more individual trunks to each selector shelf and provide a group of trunks common to two or more shelves. In Fig. 4 is shown a grading which permits shelves A and B to have access to 12 connectors. The subject will be further discussed in Sec. 212 (c).

112 (b) Trunks originate in banks and terminate in switches. In the forgoing paragraphs we were looking backward from the connectors serving the 800 group and saying "we need "X" trunks to come in here to carry the busy hour load, and they must originate in the banks of "Y" selectors. How shall we do it?"

In the same way we could look backwards from the selectors serving the 8000 group or the 80,000 group. Trunking, looking backwards, is not too hard to understand, but heaven help the novice if he attempts to look forward.

113. Inter-Office Trunking: McMeen and Miller in their 1922 edition said, "Success in Automatic Telephony came by the re-adoption of the trunking method which in manual practice, had been discarded in favor of the multiple idea of operating. As adopted for automatic telephony the method contemplates that the calling line shall be extended, link by link, until it finds itself lengthened and directed so as to be able to seize the called line in a very much smaller multiple than the total group of one office of the exchange. The ease with which the automatic system lends itself to inter-office trunking makes feasible a greater sub-division of exchange districts into office districts and particularly makes it economical, where such would not be warranted in manual working."

Direct trunking is a standard feature of practically all Strowger installations and is to be preferred, under ordinary conditions, because it facilitates the handling of calls. It is also the simplest method of obtaining a uniform numbering system, with the same number of digits in each number. This is the usual method, and it depends obviously on direct trunks from every branch exchange into every other branch exchange.

In the system just described, subscriber dial pulses need not operate the Strowger switches directly, but may be received and stored by a controlling mechanism called a "director," which, in turn, actuates the selecting switches by pulses similar to dial pulses. This expedient permits translation of the digits dialed, adding flexibility to trunking arrangements, if and as required. "Translation" may consist not only of changes in the digits, but also the dropping or addition of digits.

113 (a). The Director: In large metropolitan areas it is not always efficient to have direct trunks from every office in the network to every other office. It is necessary, in such cases, to disassociate the numbering scheme and the trunking scheme.

This can be accomplished by means of the Director, since arrangements are provided to register the impulses corresponding to the two (or three) letters of the office name, together with the significant digits of the call number, and to send out other impulses of such number and combination as are required to extend the call, link by link, over the proper trunk routes, to the terminating office; and then to operate

the selectors and connectors in that office as required to establish connection with the number dialed.

With the use of the Director and its ability to set up any required number of links to reach the terminating office, it is possible to use the tandem trunking principle to its utmost, and to be governed entirely by considerations of plant economics, without regard to traffic and operating complications that would otherwise have to be considered. On account of the cross-connecting facilities in the Director, tandem trunking can be arranged initially to meet any set of conditions and changed from time to time as required.

Purvis, writing in AT 5-25 said: "I am far from asserting that the London system will, in 20 years time, necessarily stand as a model for the world to copy, but I am confident that the adoption of the step-by-step system, with the notable addition of the "director" and other technical developments as worked out for London, represents the most practically suitable and effective way in which the telephone needs of the next generation can be met in this great and important area."

113 (b). For a general discussion of the Director, see AT 11-22; for the Director in Havana, see AT (Clapham) 9-24; in London, see AT (Purvis) 5-25; and in Johannesburg, see STJ (Catchpole) 7-32.

114 Switch Trains: The reader is now familar with the components of a simple Strowger Automatic System, and we go on to a consideration of more complicated and specialized equipment. Three distinct switch trains are usually provided in an automatic office. They are: (1) Local Switch Train, (2) Toll Switch Train, and (3) Test Train.

The local switch train provides facilities for completing: (1) connections to automatic stations from other automatic stations; (2) incoming calls to automatic stations from manual offices (via "A" operator dialing or through a "cordless" B switchboard); (3) connections from automatic stations to the manual offices (through call indicator "B" positions or through a dial service "A" switchboard); (4) connections from automatic stations to toll recording, information, repair service, dial service "A" switchboard for assistance calls, and local test desk; and (5) connections from automatic stations in the originating office to automatic stations in distant offices.

The toll switch train enables the toll operators to complete connections from toll lines to automatic stations.

The test switch trains include; (1) test train to automatic stations from the test desk; (2) verification train to automatic stations from the toll switchboard; and (3) verification train to automatic stations from a dial service "A" switchboard.

115. The Local Switch Train: The local switch train provides facilities for completing connections from automatic stations to automatic stations in the "regular" connector groups; the party line connector groups; the "trunk-hunting" connector groups; and the "level-hunting" connector groups. These terms need not be explained at this time, for their meaning will become apparent as the connectors serving the various groups are discussed in Sec. 215.

116. The Toll Switch Train: Toll calls may be, and often are, completed through the local switch train, but the use of a toll switch train has certain advantages to be described later on.

The toll switch train enables a toll operator to complete connections from toll lines to automatic stations in the various connector groups listed in Sec. 115. The toll connectors serving these various groups do not function as complete connectors, but operate in conjunction with "Toll Transmission Selectors" (which precede them in the toll switch train), to perform the functions usually classed as "connector functions." For further discussion, see Sec. 216.

117. The Test Switch Train: There are usually two test switch trains provided in a large automatic office; (1) the test train proper reached from the test desk. and (2) a verification train reached from the toll switchboard. The first switch in each train is usually a "Test Distributor" (although sometimes a "Test Distributor Selector"). The two test distributors have common access to a single "Test Connector" which appears in each of the connector groups. There is only one type of test connector, the one type forming a part of the test and verification trains terminating in the various classes of connector groups. For further discussion, see Sec. 217.

118. Party Line Service: Party line service, in its relation to connector grouping, may be given in either of two ways: (1) terminal per station, and (2) terminal per line. In its relation to method of ringing, it may be classified as: (1) fully selective, (2) semi-selective, and (3) code ringing. Each of these in turn may be divided into: (1) metallic ringing, or (2) grounded (or divided) ringing. For further discussion, see Sec. 218.

119 Air Conditioning: The control of atmospheric conditions, that is the filtering, temperature regulation, and humidity control of air in the exchange building, is considered desirable because of two factors. The first is the matter of personnel comfort. The second is the proper functioning of the central office equipment.

Under all ordinary circumstances, the atmospheric control requirements for equipment operation will fall well below the minimum requirements for personnel comfort; that is to say, if the employees can work efficiently and in comfort, the equipment need give no concern. It is only under exceptionally severe conditions, such as those that exist in certain very humid tropical places, that equipment operation needs be accorded special consideration and this

servation will apply with equal force no matter hat type of equipment is used.

or further information see AT 10-21, STJ (Crocker) 2-32 and A.E.Co. Bul.515.

20 Annoyance Trap: In the event that the called line as equipment for holding an "annoyance call", booster battery will be momentarily placed on the EC" wiper of the connector when the called party esired to lock the connection. The entire switch rain will be locked up until a switchman operates the eleasing key located on the connector.

ertain connectors do not require special line equip- ient for holding annoyance calls.

20 (a) A somewhat similar procedure is followed n calls to "Fire" or "Police". Here the "fire epeater will extend the connection to an attendant at he central office who can further extend the call to he Fire or Police Department, as desired. The fire epeater also locks up the connection and further- iore sounds an audible alarm. The attendant in the ocal office then traces the connection and makes a iemorandum of the number of the calling telephone, fter which he trips the repeater, allowing the con- ection to release."

21 Assistance Service: Complaint operators may be eached by dialing a special code, e.g. 1005. Com- plaint operators may be provided with equipment for verifying "don't answer" or "busy" reports. Com- plaint operators may also be provided with equipment or completing connections with which a calling party as had difficulty. On complaint calls the message egister is not operated unless the complaint opera- or extends the connection to the called party.

122 Automatic Switching of Toll Lines: Soon after automatic switching had demonstrated its efficiency for connecting local subscribers' telephones, tele- phone engineers began to consider the advantages of dialing connections over inter-city trunks, and there- by elininating operating time at toll switching points and at the terminating exchange where that exchange is automatic.

122 (a) Loop Dialing: Toll dialing was first applied to short lines, using a loop dialing circuit in the same manner as on sunscribers' lines. When the same met- hods were attempted on longer lines, several diffi- culties arise. Some lines were too high in resistance for accurate impulsing and most physical lines were too valuable for carrying phantom circuits and tele- graph circuits to be used for loop dialing.

For discussion of loop dialing see STJ (Granstaff) 6-40.

122 (b) Composite Dialing: Composite dialing has proved economical and satisfactory in many instances. By compositing on circuits where two lines, or side circuits, are phantomed to form a third talking cir- cuit, three of the line conductors and the earth as a common conductor are utalized for dialing circuits associated with the three talking circuits. With suit- able filters at each end of the circuit, the impulses are not audible on the talking circuits. The depend- ability of dialing over composite circuits is affected by changeable ground impedance and by earth pot- entials, especially in certain localities.

For further discussion see AT (Smith) 5-20. For discussion of composite dialing see STJ (Granstaff) 6-40.

122 (c) A.C. Dialing: Alternate current dialing is another method which has been used quite satisfact- orily on toll circuits. A.C. dialing has the advantage of being unaffected by earth potentials, but it cannot be used satisfactorily over long trunks, unless the impulses are regenerated at repeating stations. When low frequency dialing impulses are repeated several times through repeating relays, the "per cent make" of the impulses becomes distorted due to the fre- quency of the dialing current being so close to the impulse frequency.

For a discussion of A. C. dialing see, STJ (Granstaff) 6-40.

122 (d) Voice Frequency Dialing: None of the above methods of dialing were capable of being used over carrier telephone or radio telephone circuits. Nor can they be used on physical circuits using voice cur- rent repeaters unless special means are provided at each repeater to by-pass the dialing impulses.

Voice frequency dialing was introduced to overcome the limitations of previous methods of toll dialing. It is suitable for any type of circuit, and is, briefly, a means of dialing using alternating current of a fre- quency in the voice current range.

122 (e) For further discussion see STJ (Wicks & Granstaff) 12-39, and STJ (Hirch) 9-41. For a dis- cussion of voice frequency dialing see STJ (Grandst- aff) 6-40.

123 Automatic Toll Board: The Automatic Toll Board - sometimes referred to as the Cordless or Remote Control Toll Board - has successfully met the widest variety of toll operating conditions and practices both in the United States and in other countries.

The original developement of the Automatic Toll Board naturally centered round the Strowger switch and the conventional horizontal relay as switching and con- trol mediums. Experiance with local automatic switching had indicated that these two units of appara- tus would provide a full measure of reliability and flexibility.

For further discussion see AT (Smith) 9-31. STJ (Sor- ber) 12-32. STJ (Sorber) 12-37. STJ (Sorber & Smith) 6-39, ATJ (Sorber) 3-40. AER 9-40 and STJ (Voss) 9-41.

124 Automatic Toll Ticketing: In an automatic multi-exchange area in which a toll charge is made for inter-office calls, Strowger Automatic Toll Ticketing (SATT) apparatus may be employed to automatically issue toll tickets. This eliminates mixed manual-automatic operation, except for the long distance toll calls.

The SATT system consists of the following components: (1) a repeater for storing the terminal number of the calling party, the exchange code, terminal of the called party, and rate applicable to the call; (2) a converter to determine the class of rate, the route to the called exchange, and whether the calling party has a right to toll service; (3) a detector to determine the calling line; (4) a printroller which collects all the information, including the time of day, and passes this to the printer; (5) the printer unit which issues a ticket with the calling party's number, the called party's, the date, the time, rate code, conversation time, and computed cost of the call: (6) the time and date unit.

For further discussion see STJ (Ostline) 6-40.

125 The C.A.X.; The Community Automatic Exchange has been designed to meet the telephone requirements of exchanges serving towns or rural communities. It is made up of standard Strowger equipment and while it can be utilized as an isolated system, it is usually installed with trunks to a neighboring exchange, which may be either manual or automatic.

Individual and party line service can be given to town subscribers and rural line service to the country subscribers. All calls are made by dialing.

For further information see AT (Barry) 2-29, AT (Obergfell) 7-19 and A.E.Co. Bul. 819.

126 The Call Indicator: It is desireable that an automatic station be able to obtain connections with any other station in the same local area by the simple method of dialing the call number of the desired telephone, regardless of whether or not all the stations in the area are automatic. In order to give this service, certain operators' positions in each manual office may be equipped with call indicator equipment.

A call indicator has as many groups of numbers from 0 to 9 as there are digits in the directory numbers. See Fig. 3, Sec. 213 (e). Normally the figures appear very faintly. A lamp is placed beneath each figure and, when lighted, displays that figure quite prominently. When an automatic sunscriber dials a telephone number assigned to a telephone in a manual office, the first digit causes the first selector to extend the connection to that particular office. The succeeding digits each operate a register, several sets of which are associated with each call indicator. When all digits have been registered, a set up pilot lamp on the operator's key board is lighted, and at the same time the number set up on this particular set of registers is displayed by the call indicator lamps. At the same time an assignment lamp associated with the calling trunk lights and thus identifie the cord to be used. The operator then inserts th plug associated with that cord into the multiple jac of the line indicated by the number displayed upon th call indicator, whereupon this particular set of reg isters is released and the call indicator is left fre to handle other calls.

Calls from the manual office to automatic subscri bers are usually handled by providing dials at the A positions of the manual switchboard. See Sec. 213(d)

127 Class of Service Tones: Subscribers are generally divided as to their several classes of service Some may be denied toll service, or furnished such service only on a prepaid or other special basis Other classes include paystation or coin box toll stations, individual lines, party lines on which precautions to charge the correct subscriber may be necessary, etc. To inform the toll recording operator (or other operator in case of other services) of the class of service the subscriber is entitled to, a "discriminating" tone may be imposed on the circuit which the operator may hear. The lower eight strips in the terminal assembly provide the means for connecting any one of the various tones to any line in the group. Four tones, supplied from a tone machine, are connected to four terminal strips. A tone cable connected to two strips is arranged so that any of the four tones may be connected to any of the 100 lines. To place a discriminating tone on a line it is necessary only to solder together a contact on the proper tone strip to the proper contact of the tone cable. Class of service tone equipment is provided only when local operating conditions require this service.

128 Code Call Service: The P.A.X. Code Call Machine, as its name implies, is designed to operate as an integral part of a Private Automatic Exchange. Each telephone, on a system so equipped, stands ready to page a wanted party upon the dialing of the general code call number, plus the code call of the party desired. The code call signals, chimes, bells, horns, whistles, or lights - sound or flash the code over all building and grounds or only in the portion thereof desired.

More than being a mere man-finder, the P.A.X. Code Call provides for immediate private telephone conversation with the called party who, upon hearing his individual code sounded, goes to the nearest phone and dials the code answer number. The dialing of this number immediately connects the wanted party with the calling party, and the code signals automatically cease sounding. The conversation now takes place with typical P.A.X. privacy.

"Code Call Service" has many uses in offices, factories, hospitals, and other institutions. Soft sounding, loud sounding, or visual signals, as conditions warrant, may be employed even on different parts of the same circuit. For small installations, 10-code capacity machines are available, while for other installations, capacities up to 125 three-digit codes

available. Combinations of two and three digit es may be used.

e P.A.X. type of code call is not to be confused h the motor-driven isolated-type which is em- yed with manual branch exchanges. The P.A.X. de Call is entirely automatic, and hence, it differs h in principle and in method of operation from the lated "manual-set" type described in A.E.Co. . 554 and 641. All equipment for the P.A.X. Code contained in a small metal box which is mounted or near the P.A.X. switch-cabinet. No special ention or maintenance is required.

r further discussion of the P.A.X. Code Call see .Co. Bul. 670.

(a) Code Call Service Via the Connector: In two it systems, i.e., those without selectors, the code i machine is connected to the connector terminals.

r this reason, its call number must be a two-digit nber. Usually 70 is selected as the call number 79 as the answer number. With the code mach- on connector terminals, some arrangement must made to permit the code dial impulses to pass ough the connector into the code machine. If the nectors are of the switch-through type, dial pulses l pass through to the pulsing relay of the code chine.

vever, if it is of the non-switch-through type, and y likely it will be, cam springs must be fitted to se when the wiper arm reaches, say, "0" on the ' level. These contact springs are so wired that itional dial pulses (repeated by connector relays) l be automatically directed over the positive line ectly to the rotary magnet of the first minor itch of the code call machine. These contact ings are necessary because the talking circuit en- ing the non-switch-through type connector is sep- ted by condensers from the talking circuit leaving the bank contacts.

Complaint Observation: Service observation uld not be confused with complaint observation, ough the methods and equipment used in both es are quite similar. Complaint observation is investigation of specific cases of reported trouble ch cannot be located by the regular maintenance lities. The complaints reported by subscribers ually include one or more of the following: (1) eives wrong connections: (2) Does not receive oming calls: (3) Receives "annoyance" calls: (4) nsmission difficulties, and (5) Overcharge when metered rate.

e complaint observer obtains such information as l either verify a subscriber's complaint and furn- information which will assist in remedying it, or e will indicate if and how the dissatisfied sub- iber is in error. This information is obtained, as service observation data, without in any way inter- ing with the normal operation of the observed line or indicating to the subscriber that observations are being made.

The discussion of service observation, Sec. 165, will serve to clarify further the distinction between service observation and complaint observation.

130 The Condenser: It has long been common practice to place a condenser of suitable size around a pair of break springs which open a relatively heavy current flow. The contact being normally closed, the condenser is naturally short circuited and there is no difference in potential between its plates. When the contact is opened the short circuit is removed from the condenser at the same time as the excessive potential is built up. The condenser, being in an uncharged condition, will now absorb a certain amount of current depending upon its structure; thus the momentarily excessive potential will charge the condenser rather than jump the air gap between the contact points. By experimentation the condenser may be varied until a point is reached at which the spark between the contact points practically disappears.

The condenser is now charged at a potential much higher than the ordinary voltage of the circuit. As the momentarily high voltage recedes, the condenser will gradually discharge back into the circuit until its difference of potential has fallen to that of the normal circuit. As the circuit usually has a fairly high impedance, this return of the condenser to normal will be comparitively slow.

From the foregoing it will be seen that a condenser offers ample protection to a contact which is only operated on rather infrequent occasions. Further complications enter the case, however, when the contact is one which is rapidly making and breaking. At the first break of the contact the condenser will become charged as explained in the preceding paragraph. Immediately the contact again closes, and as the springs approach each other a point is reached at which the condenser will discharge through the minute air gap separating the contact points. The circuit over which the condenser discharges has no inductance and very little resistance, as the air gap is continually growing smaller even as the discharge takes place. The current flowing is the algebraic sum of that normally flowing in the circuit and that produced by the condenser, which is, of course, limited by its capacity.

The increase in the flow of current is at times sufficient to heat the contacts to the welding point. This phenomenon was first noted in connection with the line relay contacts of selector switches. The switch would operate perfectly to the 0 level some half dozen times, then on the next operation the springs would seem to stick or weld together. Usually this merely caused a hesitation and did nor result in the failure of the switch. In a few instances the springs remained in contact with a perfectly welded connection between the contact points.

After considerable investigation, the theory outlined in the above paragraphs was advanced to explain the failure of operation. Obviously the proper way in which to overcome this difficulty would be by the insertion of a certain amount of impedance between the contact and the condenser. This impedance will lower the current discharge by the condenser below the point at which the contacts would weld. It would not do, of course, to have too great an impedance or the effect of the condenser would be entirely neutralized.

For several years all spark condensers used with automatic apparatus have carried a small, non-inductive german silver resistance, which so regulates the discharge as to insure that excessive current will not flow through the various contact points. By the use of this ingenious scheme, it has been possible at a number of places, to make use of an alloy contact point which gives as efficient service as platinum, and yet is much more economical.

130 (a) For further discussion see AT 1-20.

131 Conference Service: Conference service consists of an arrangement whereby a number of branch exchange telephones are connected to a common talking line. There are three types of conference service - "Meet-Me," "Progressive" and "Fixed Group" - as described below.

131 (a) "Meet-Me": "Meet-Me" conference service provides for any number of P.A.X. or P. A. B. X. parties, limited only by the number of connectors available, to call a designated conference number to connect them to a common talking circuit. The desination "Meet-Me" is derived from the fact that persons who are to confer are told in advance when the conference is to be held. Any party may withdraw from the conference at any time without interfering with the conference.

Conference service is provided for on a certain bank contact of a certain level. The "+" and "-" lines of the conference number are multipled from bank to bank, but the privates are not so multipled. The private of the conference number in a given bank is connected to the "conference private" jack of the one connector having access to that particular bank, thus making it possible for any number of connectors to switch through to the conference number. Each connector has a "conference private jack". The equivalent shelf jacks are not multipled-but are con - nected as shown above.

131 (b) "Progressive" conference service permits any P.A.B.X. party to call a conference by dialing first a special conference number and then the regular telephone numbers of the P.A.B.X. parties wanted (any number up to 18). As each person answers, he is asked to wait on the line and the conference starts as soon as the last person answers. No telephones other than those called can enter the conference but additional stations may be called in or the conferees may withdraw at will while the conference is in progress. When wanted, the equipment can be wired so as to limit the privilege of calling conference to on station.

131 (c) "Fixed-Group" conference service is suit able where telephone conferences are generally call ed among the same group of people. If permits an P.A.B.X. party in a fixed group (not more than 1 stations to a group) to call all other members b dialing a single number. To prevent the called part ies from confusing the conference call with an ordin ary call, a distinctive long uninterrupted ring is pro vided. If any stations are busy, their existing call are cut off and the lines are immediately connecte to the conference circuit. Stations not in the grou cannot cut in on the conference and any station in th group may withdraw at will. More than one fixe group can be arranged in a P.A.B.X. switchboar (and some P.A.B.X. stations can be included in sev eral groups) but each group is entirely independer of the others.

When desired, one or more executive stations in conference group may be equipped with a lamp signa cabinet arranged with a lamp for each line in th group. When the executive calls a conference, th corresponding lamp in the cabinet lights as eac station answers. He may dismiss any parties at an time and as their lights go out, hold a conferenc with the others with the assurance that the person dismissed cannot hear what is said.

132 Connectors of Large Capacity: Under certai conditions there is an economic advantage in usir banks of large capacity. Generally speaking, th greatest economic value is had when the proper rati is maintained between bank cost and switch cost. Bu under certain conditions this ratio value can be ig nored; for example, when a large bank eliminates rank of switches.

For the above reason, a connector has been develop ed which will serve a total of two hundred lines.

The mechanics of this switch are the same as that the ordinary connector, the difference being that th wipers have access to two line banks and one 200 contact private bank. If the switch is moved up and "XX" steps, one set of wipers will be standing on th bank contacts of the "XX" line in the first hundre group, while the other set of wipers will be standi on the "XX" line in the second hundred group. Th problem then is to select one or the other set of wi ers.

(A) For further discussion see STJ (Salvesen) 6-37.

132 (a) Wiper Selection Made at Banks of Precedi Switch: This particular connector has two appea ances in the banks of the last rank of selectors. Wh selected from the first appearance, the first set wipers is selected and the "XX" station in the fir hundred will be rung; but if this connector is s lected from the second appearance, the second s of wipers will be selected and the "XX" station the second hundred will be rung.

is connector is selected by way of three-conductor unk (+Line, -Line and C) from each of two appearces in the banks of the last rank of selectors; and equipped with seven wipers (+1, -1, C1, +2, -2, C2 d EC2). The EC wipers are present because this rticular connector is a trunk-hunting connector in e second hundred group.

2 (b) Wiper Selection Made Within the Connector: hen the wiper selection is to be made within the nnector, the wiper selecting digit must operate me circuit device to cause the change of wipers.

2 (c) By use of Counting Relays: In this particular nnector (intended for use only in a 200-line P.A.X.) e third digit from the last actuates counting relays; the digit "1" is dialed, the first set of wipers is lected; while if the digit "2" had been dialed the cond set of wipers would have been selected.

is method of "hundred group" selection is emoyed in the individual-line type.

2 (d) By Use of Minor Switch: In this particular nnector, the third digit from the last is received a minor switch. If the ringing digit is from 1 to 5, clusive, the first set of wipers will be selected but the ringing digit is from 6 to 0, inclusive, the secd set of wipers will be selected.

is method of "hundred group" selection is generly confined to connectors which will eventually rve party lines

2 (e) 200-Line Connector Having 20 Rotary Steps: e connector under discussion is provided with two 0-contact line banks and one 200-contact private nk, and equipped with two sets of wipers (+, - and . The first set of wipers is mounted in the usual sition on the shaft, but the second set is offset so t they will engage their first bank contact upon e eleventh rotary step, their second bank contact on the twelfth rotary step, etc.

e first hundred lines (90 actually, the "0" terminal each level cannot be used) are reached by dialing o digits on this connector, and the full second huned by dialing three digits, the second digit always ng "0". Cam springs mechanically operate on the h rotary step, permitting the dialing of the additnal rotary digit.

3 Connectors of Small Capacity:

3 (a) Using 11-point Rotary Switch: The capay of this connector is ten lines, the lines being mbered from 1 to 0, inclusive. Bank contact 11 is ed for functional purposes.

3 (b) Using 25-Point Rotary Switch: The capacity his connector is twenty-two lines, which are asmed numbers in three groups.

e first group is assigned line numbers 1 to 9 insive, and are connected to contacts 1 to 9 of the connector banks. The second group is assigned numbers 01 to 09 inclusive, and are connected to contacts 11 to 19 of the connector banks. The third group is assigned numbers 001 to 004 inclusive, and are connected to contacts 21 to 24 in the connector banks.

Bank contacts 10 and 20 are vacant "stopping" contacts and cannot be used for line terminals while bank contact 25 is used for functional purposes.

134 Conversation Timing: In small exchanges and especially on party lines, it may be desired to time conversations and release the connection at the conclusion of the timing interval. A warning signal is usually given to the parties on the line shortly before disconnection.

134 (a) Link Timing Relays (Line Lock Out): In addition to conversation timing described above, the finder-connector link may be timed under certain conditions which tend to tie up the exchange equipment. A link will be released within a given time on some C. A. X.'s if the calling party fails to dial, if the call is not answered, if the calling party fails to disconnect, or if a "permanent" line seizes a link. Thus this timing feature prevents exterior line conditions from tying up valuable conversation links.

135 Dial Controlled Ringing: As used in certain small P.A.X's, the connector may be arranged to afford dial controlled ringing, whereby the calling party may cause the called line to be rung by dialing additional digits (digit 2 for short ring, 8 for long ring) after the selection of the called line is complete.

136 Direct-Line Service: "Direct-Line" service is ideal where two stations of P.A.B.X. systems call one another very frequently. With this service, when the receiver or handset is lifted at either station, the bell at the other station is automatically rung. It requires a separate line between the two telephones with separate ringers and a switching key at each telephone to connect it to its regular P.A.B.X. line. Any number of pairs of telephones in a single P.A.B.X. may have "Direct-Line" service but each pair is separate and distinct from the others.

136 (a) Executive Key-Calling Service: This service permits an executive to call individually any number of P.A.B.X. stations up to 25 - without dialing or lifting the receiver or handset - merely by operating keys in a small cabinet furnished at the executive station. The keys are directly connected to the station most often called by the executive and operating any one of them causes the bell at the selected station to ring continuously - thus indicating that an executive is calling. If the called line is busy, the call remains on the line but the telephone is not rung until the line is free A low-toned buzzer in the executive's cabinet sounds while the called bell is ringing. When it stops, the executive knows that the call has been answered and lifts his receiver or handset.

Normally the executive's telephone is connected to his P.A.B.X. line and is used as any other P.A.B.X. station but when a key in the cabinet is operated, the telephone is automatically disconnected from the P.A.B.X. line and connected to the line selected.

Any number of key cabinets may be installed in conjunction with a P.A.B.X. switchboard but each one is separate and distinct from the others.

136 (b) Executive Loudspeaking Direct Line System: This system, used in conjunction with a P.A.X., gives the executive quick direct-line communications with a selected group of subordinates by means of keys on the Master Cabinet.

For further discussion see A.E.Co. Bul. 346.

137 Discriminating Service: In a P.A.B.X. it oftentimes is desirable to limit certain stations to the making of inside calls. This is more likely to be the case where the service to the main exchange is metered.

When the call is made from a subscriber entitled to service on the trunk-hunting level the incoming discriminating trunk will be grounded, then, and then only, will the connector extend the call to the main automatic exchange. A similar feature is sometimes called "Restricted Service."

The restricted telephones can, of course, receive incoming calls the same as an ordinary telephone. If it is desired to restrict certain lines from receiving incoming calls it is merely a question of opening up the private multiple and grounding the private bank contacts associated with these lines in the banks of the incoming connectors. These connectors are located at the P.A.X. and are the terminals of trunks leading from selector repeater banks at the Main Exchange.

138 Executive "Right-of-Way": "Right-of-Way" service, as the name implies, gives an executive in a P.A.B.X. system a preferential service when calling other P.A.B.X. stations. It is usually arranged so that when an executive receives a busy signal when making an urgent call, he can switch his telephone to a separate "right-of-way" line, redial the number and cut-in on the busy line. This does not disturb the existing conversation and the executive may interrupt or nor, as he chooses. If he waits, ringing current is sent over the called line as soon as it becomes idle.

138(a) Using Individual Connector: This connector, in a two-digit system, is directly connected to an executive's line in place of the usual line equipment.

When a busy line is called, the executive is able to monitor the connection; and, if he wishes, may speak to the conversing parties. When the called line becomes idle, the connector will start the automatic ring in the usual manner.

138(b) Using Common Connector: This particular connector is seized over a three-conductor trunk (+ Line, -Line and C). When a call made from an executive line encounters a busy line, the busy tone may be removed and the line monitored by operation of a key at the executive telephone which grounds both sides of the line. This causes the connector to disregard the busy condition and complete a talking path.

When the called line becomes idle, the connector will start the automatic ring in the usual manner.

139 Fire Alarm: The P.A.X. telephones alone, may always be used for emergency alarms with the fire marshal's telephone equipped with a loud ringing bell. More elaborate fire alarm systems require special equipment. The equipment used consists of a number of closed circuit alarm boxes placed at convenient points, a supervisory panel at the gate house or fire marshal's office, and a code sender. If upon the outbreak of a fire a pull-box is operated, the code sender automatically sends out the fire code for that box to all of the code call signal devices. As always an alarm may be sent in by dialing the fire marshal's telephone. The fire marshal, after receiving the information over the telephone, may send out the code call of the box nearest to the fire by operating a key which starts the code sender.

140 Floor Plans: In planning a Strowger exchange there are certain fundamental considerations which should be observed if the best results are to be obtained both from the equipment and from those in charge of its operation and maintainance. These considerations have to do with the type, construction and structural details of the exchange building, and with the layout and distribution of the various units of equipment within the building in order to save intra-office cabling costs, increase operating efficiency and make maintenance easier.

For further information see AT (Herrmann), 5-26 and A.E.Co. Bul. 309 (Large Exchanges) and 325 (Small Unattended Exchanges).

141 Impulses, Light and Heavy: There are certain limitations which must be imposed on the subscriber lines for successful operation of the Automatic equipment.

The two line conditions which should be considered when it is desired to operate common-battery dial equipment are "line leakage" and "line loop resistance." Line leakage refers to the resistance offered by the insulation between the two wires of a line or from the line to ground. In the case of drop wire cracked insulation plus moisture will greatly lower this resistance and permit large currents to "leak" across the line. On the otherhand, line loop resistance is the metallic resistance of the line wires (exclusive of the telephone instrument) from the exchange to the subscriber and back.

With dial speed between 8 and 12 impulses per second, a line may have a maximum non-inductive loop

sistance of 1000 ohms and no leak, or 15,000 (some-mes 7,500) ohms leak resistance and no loop re-stance. These two values represent extreme con-ions. Intermixture of the two results in better erating conditions.

practice, every line has loop resistance and some akage. For each value of loop resistance, there is, course, a limit to the leakage for satisfactory op-ation.

understand how the operating range of a two-otion switch is determined, refer to Fig. 1. The bscribers line in the figure has no leak resistance, t rather a high series resistance (line loop).

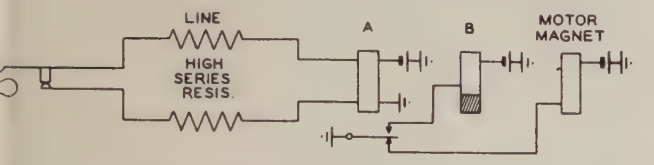



Fig. 1 - Effect on Dial Pulses of High Series Resistance.

there were no line resistance, pulsing relay A uld operate almost instantly when the subscriber's al spring closed, and relay A would release almost stantly when the dial springs open on an impulse. nen A closes, it sends current to the slow relay B d when A releases, it sends a pulse of current to e motor magnet. If there is too much resistance in e line, relay A will be slow to pull up and will fall ay quickley on dial impulses because of the low gnetic saturation and lack of a shunt. This sit-ion gives relay B too little current to hold it up d gives the motor magnet too long a pulse, some-nes called a "heavy" pulse.

as in Fig. 2, there is negligible line loop resistance d low insulation resistance, the high leakage cur-

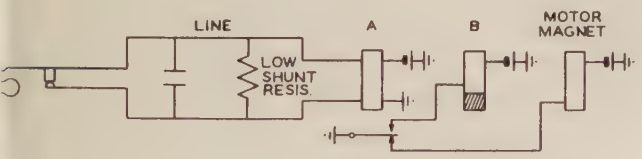



Fig. 2 - Effect on Dial Pulses of Low Shunt Resistance.

nt, flowing across the line, will hold A partially gnetized even when a dial impulse has opened the e circuit. A will thus operate too fast at the con-usion of a dial impulse and release too slowly at e beginning of a dial pulse. The shunt will tend to intain A operated at break not only because of the ttery current which will flow in the resistance, but so because of the self-induced current from the line ay coil. Since A will remain operated overly long. motor magnet which will now get too short a lse, sometimes called too "light" a pulse. High pacity between one side of the line and the other, as presented by the condenser in Fig. 2, further adds the effect of the low shunt resistance.

In order that a switch may operate through as wide a range as possible, it is tested (varied) and adjusted first with a series resistance and then with a shunt resistance.

For Line and Trunk Standards see Sec. 144.

142 Information Service: Information operators are called by dialing a special code, e.g. 1003. Connections to information operators are made by selectors only; therefore there is no reversal of polarity on the calling line, and no operation of message registers or collection at pay stations.

For further information see A.E.Co. Bul 409.

143 Intercepting Service: Calls terminating upon unused selector levels, calls for idle numbers, changed numbers, or disconnected numbers, are automatically switched to a special operator who is provided with appropriate records. This function is comparable to the service rendered through the use of "multiple markings" on a manual switchboard. The special apparatus cares not only for individual-line station calls but for calls for any station on a party line as well.

Intercepting equipment may also be used for intercepting calls from individual stations of subscribers who have been denied service. The answering equipment is such that the message register of the calling line will not be operated.

For further information see A.E.Co. Bul. 410.

144 Line and Trunk Standards: The condition of the subscribers' loop and the trunk lines is of the greateat importance in giving telephone service, no matter what kind of central office apparatus is being operated. Even the best telephones and the best switchboard equipment cannot overcome poor line construction. For effect of line conditions upon impulsing, see Sec. 141.

For further information see AT (Wicks) 2-19 and A.E.Co. Bul. 526.

145 Lock Pulsing: Lock pulsing was developed to provide better impulsing on heavily loaded party lines. As the name implies, each pulse is interlocked with the operation of the switch (or repeater) to assure complete operation even though the impulses from the dial are badly distorted by the line (or trunk) conditions. For a complete discussion of the subject, see STJ (Calhoun) 12-34 and STJ (Grandstaff) 6-40. As to line and trunk standards, see A.E. Co. Bul. 536.

146 Message Registers: Message registers of the type used in manual systems may be furnished for individual line service. They are mounted upon message register racks which can be located as desired. Each register is associated with the line equipment, and when the line becomes connected to a trunk, the register becomes associated with the trunk through

a relay whose winding is normally in the trunk circuit. When the called station answers, the connector reverses the polarity of the trunk causing this relay to operate and actuate the message register which, for the time being, is associated with it. The relay in question locks up and thus insures that the message register can only operate once for each completed call.

For further discussion see AT (Smith) 7-19.

147 The Minor Switch: A minor switch consists of a bank assembly, wiper assembly, and the mechanism required to move the wipers. The switch has rotary motion only.

As shown in Fig. 1, the bank assembly has ten sets of contacts arranged in an arc similar to one level of a

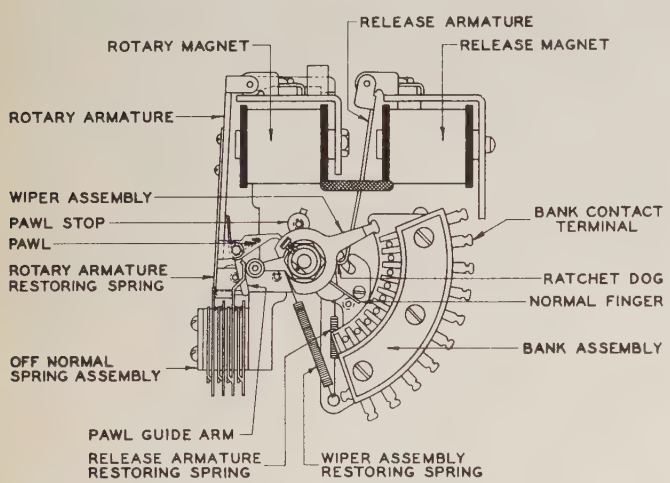



Fig. 1 - Mechanics of the Minor Switch.

Strowger switch bank. Actually, the bank assembly on a minor switch may be one, two, or more levels deep depending on the circuit requirements. Each level has associated with it one pair of wiper springs. Usually, the upper surface of each level consists of ten individual contacts, while the bottom surface is a solid segment (called a contact common). The pair of wiper springs merely closes the circuit from the particular top contact upon which it stops, to the contact common.

To control the movement of the wiper assembly, two electromagnets are furnished. One is for rotary stepping and one for release. The armature of the rotary magnet carries a pawl which operates the rotary mechanism. When dial impulses energize the magnet its armature is attracted, and the pawl engages one of the teeth on a ratchet wheel, causing the ratchet to turn on its axis. The wiper pairs are rigidly assembled to this ratchet and thus step with it. The number of steps corresponds to the digit dialed. A flat steel spring attached to the rotary armature provides restoring tension for the armature after each energization of the rotary magnet.

The ratchet dog, which is merely the hooked end of the release magnet armature, is controlled by the release armature restoring spring and the magnet. It engages the teeth on the ratchet wheel and retains the wipers on the contacts to which they have been stepped by the rotary mechanism. As the wipers step, the wiper assembly restoring spring, which is attached to the wiper assembly, increases its tension. This tension restores the wipers to their normal position (one step off the first contact) as soon as the release magnet operates and disengages the ratchet dog from the ratchet wheel.

The minor switch is equipped with a spring assembly called the M.S.O.N. (minor switch off-normal) springs.

These are actuated on the first rotary step and usually serve two functions. The first of these is concerned with the release circuit of the minor switch itself. The second function is concerned with the circuit to the release-signal of the connector switch with which the minor switch is associated. In regard to the latter function, both the Strowger switch and the minor switch have to properly restore to their normal positions, or else the connector release signal will operate to give a warning.

148 Monitoring Service: In schools, penal institutions and similar institutional installations it is often desirable to have a means of supervising and listening-in on branch exchange telephone calls. With P.A.B.X systems, two types of monotoring service are available - "Plug-In" type and "Dial-In" type.

"Plug-In" monitoring service provides means for determining when conversations are taking place and also for listening in. The equipment at the monitoring station consists of a cabinet containing lamps and jacks (one each for every conversational path in the switchboard) and a hand telephone and plug. A lamp lights whenever a call is made and the monitor can plug into the corresponding jack and listen without disturbing the conversation. The handset is equipped with a transmitter cut-out button, but the monitor may enter the conversation if he so desires.

"Dial-In" monitoring provides for listening-in service only. Through the use of a regular P.A.B.X telephone connected to special equipment in the switchboard, the monitor can dial any station of the P.A.B.X. system and be connected to the selected line without disturbing the conversation if the line is busy and without ringing the station bell if the line is idle.

More than one monitoring station can be provided in a P.A.B.X. system but each is entirely separate and distinct from the others.

149 Multiple Markings: In manual practice it is customary to use marks and designations in the multiple in order that the operator may derive instant information relative to the subscriber she is about to call. Most of the information desired may be covered by the following headings: (1) Change number service. (2) Take out service. (3) Denied service for non-payment or temporary disconnections.

) Toll service restrictions. (5) Pay station ser-ce. (6) Measured rate service. (7) P.B.X. trunk ouping. (8) Certain types of party line service.

automatic practice items Nos. 1, 2 and 3 are hand-d over the so-called traffic trunks carried to the formation desk. In some cases where subscribers e to be denied service because of lack of payment, addition to their normals being connected to traffic unks leading to the information desk, their lines are nnected to trunks terminating at the cashier's of-ce. Persons calling such numbers will reach the formation operator, who will advise them of the emporary disconnect." Should the disconnected rty attempt to call, he will be answered by the shier's department, who will inform him of the ason for the service restriction.

em No. 4 is taken care of by connecting any one of ur different tones to the line in question. This tone audible only to the toll recording operator and in-cates to her the status of the calling party relative the originating of toll calls.

em No. 5 is taken care of in the same manner. Loc-service from pay stations to other local stations is ll automatic and, therefore, requires no super-sion. On calls from toll to pay-station, the toll erator has two means of knowing that the called mber is a pay station. In the first place, the num-r of the line would indicate it to be a pay station. a further safeguard a distinctive tone is placed on pay-station lines which becomes audible to the l operator when a pay-station line is called, the ne remaining on the line until the pay-station ans-rs.

m No. 6 is taken care of automatically by means of eter equipment.

m No. 7 is automatically taken care of in the banks the rotary connectors which serve P.B.X. groups.

m No. 8 is automatically taken care of in the banks the connectors serving the various groups of party es.

r further information see AT (Clapham) 9-20.

0 Outgoing Secondary Line Switches: Since a sel-tor has access to not more than ten trunks on a ven level the inter-office trunks must be run in oups of ten or less if they are to be carried direct-from the selector banks through the repeaters to distant office. In order to take advantage of the onomy of large trunk groups, outgoing secondary e switches may be used. These switches are in-rposed between the first selectors and the repeat-s. The trunks from the multiple banks of the sel-tors terminate at the secondary line switches. The unks from the banks of the secondary line switches e extended through the associated repeaters to the er-office trunks. The trunks from the selector nks to the secondary line switches are taken rough the trunk I.D.F. The trunks from the sec-ondary banks to the repeaters are taken through the I.D.F. in the repeater board.

The selectors in each group, working through the particular level representing trunks to the distant office, have access to ten secondary line switches, each of the latter being in a separate group. Each group of secondary line switches, in turn, has access to ten or less trunks. In theory, then, through these successive choices of outlets, each selector may reach any trunk in the entire group.

In practice, this arrangement never quite reaches the efficiency of a single large group of trunks reached directly, because of the fact that the ten outlets from one group of selectors may all be in use while idle outlets are available from other selector groups. Nevertheless, it often happens that the saving in trunks is sufficient to warrant the cost of the secondary line switch equipment.

By the use of rotary outgoing secondary line switches theoretic groups up to 250 trunks may be made available from a level in a selector bank. In order not to introduce a delay in trunk hunting the rotary line switches may be made to operate on a preselecting basis.

For further discussion see Sec. 181.

151 Pay Stations: Coin collectors arranged to automatically collect single coins on calls to local Automatic stations may be provided. They are of the post-payment type, thus permitting the call to be made in the usual way. The calling party can hear the answer of the called party, but the transmitter of the calling telephone is rendered inoperative until the required coin has been deposited. The operation is accomplished over the standard Strowger circuit and does not require special voltage or equipment at the central office.

Prepayment telephone of both the single and multi-coin type or also used. The prepayment type prevents any call being made until the required coin is deposited. On calls to Automatic stations the coin is collected, automatically when the calling party hangs up his receiver, assuming that the called party has already answered. If the called party has not answered, or the line is busy, or the call has been made to a free line, the coin is returned through a chute when the calling party hangs up his receiver.

The multi-coin feature is used for toll calls, in which case collections are handled manually. This scheme necessitates the use of a special voltage for collection, and the addition of special central office equipment installed on the trunks between the line switches and selectors. Therefore pay station lines of this type must be segregated in separate line switch groups.

In either case collection is dependant upon a reversal of polarity, and therefore no coins are collected when special service calls are made. If so desired the

pre-payment telephone can be arranged so that special service numbers may be called without depositing a coin.

When the toll line operator dials a pay station number she must remember to collect for payment. As an additional safeguard it is usual to provide a distinctive tone on such connections until the called party answers.

For further information see AT (Smith) 7-19, STJ (Walker) 3-32, and A.E.Co. Bul. 311 and 328.

152 The P.A.B.X.: The private automatic branch exchange (P.A.B.X.) is similar to a private automatic exchange (P.A.X.) except that facilities are provided for making calls to and from the public exchange through the P.A.B.X.

Simplest arrangement is to list the P.A.B.X. numbers in the telephone directory. The calling party then dials into the P.A.B.X. However incoming calls from the public exchange are usually completed by an attendant who knows the P.A.B.X. number of the wanted party and who can render personal service to the calling party. The attendant may have one of two types of cabinets before her: (1) The familiar floor type with a complete manual multiple of all P.A.B.X. telephones. Connections with incoming calls are set up manually using cord circuits. (2) Turret Type cabinets are placed on a desk or table. Connections are set up by dialing into the P.A.B.X. Supervisory lamps and keys for answering and releasing the various trunks appear on its face.

Outgoing calls (P.A.B.X- to public exchange) may be handled in any of several ways. One method requires the service of the attendant to extend the line to a public exchange trunk. The attendant may thus exercise discrimination in granting trunk service.

Another method of making outgoing calls permits the calling party to seize public exchange trunks directly by dialing the single digit assigned. The trunks are usually connected to the "9" or "0" level on the connectors (or selectors if present). The connectors when arranged for this service rotate automatically on the selected level to find a free trunk. Under restricted service, only certain telephones may obtain trunk service.

For further discussion see A.E.Co. Bul. 818.

152 (a) Passing Call Feature: Certain P.A.B.X's, afford trunk transfer service, in which case calls from the central office are indicated either audibly or visibly, the signal being multipled to various locations for use when the system is unattended.

These calls can be answered from any non-restricted station by dialing a predetermined number. If the call is for some other station, the person answering presses the push button on his telephone. This holds the trunk call, but frees the answering telephone. The number of the desired local station is then dialed. On being informed of the trunk call, that person then presses his push button, which causes the trunk call to be instantly transferred to his telephone. The person originally answering then receives busy tone, and hangs up.

153 The P.A.X: The Private Automatic Exchange, abbreviated P.A.X. is an automatic intercommunicating system which serves business houses, institutions, residences, and ships in the same manner that a Community Automatic Exchange serves a community. The P.A.X. is composed of the regular Strowger equipment arranged and adapted to fit the requirements of intercommunicating systems and renders the same quality of service as that furnished by public automatic exchanges. These switchboards are made in a number of standard types and sizes. Size ranges from three telephones to any number desired. Switchboards once installed may be increased in capacity as the need arises. A 100-line capacity system may be thus increased to, say a 1000-line system or one of intermediate size.

The P.A.X. is an isolated telephone system serving a single building or group of associated structures, often though a P.A.X. may be connected to other telephone systems. When a P.A.X. is arranged to permit calls to be made to and from the public exchange, it is called a Private Automatic Branch Exchange (P.A.B.X.)

The P.A.X. as an isolated system has a number of advantages. It permits "double track" telephone service. An inquiry on the city exchange phone may be investigated and answered over the P.A.X. while the city call is waiting. The private system also reduces the number of calls which must be handled by the manual switchboard attendant and gives general communications efficiency.

153 (a) Small P.A.X's: Most P.A.X's with capacities for 25 or fewer lines employ rotary linefinders and rotary connector switches.

153 (b) Moderate and Large Size P.A.X's: These are generally of the lineswitch type though linefinders are employed on some. Exchanges with an ultimate number of lines less than 100 have Strowger connectors while larger systems require selectors. In other words, a Private Automatic Branch Exchange of moderate to large size employs practically the same switch train as a city exchange of comparable capacity.

The switchboards are usually enclosed in steel cabinets. In exceptionally large exchanges, however, the switches are rack mounted with individual dust covers. Either type of installation may be expanded by adding additional cabinet sections to the former and more shelves or racks to the latter. The unit system of mounting the switches on the shelves makes the addition of equipment relatively simple.

153 (c) Special Services: P.A.X's may be equipped to render various services including Code Call

atchman's Supervisory and Recording, Conference, xecutive Right-of-Way, and Alarm. Other services s required in schools and special institutions are vailable. In addition, arrangements can be made to mit service on some telephones and to give special ivileges to others.

53 (d) For further discussion see AT (Keith) 7-19, nd A.E.Co. Bul. 818.

54 Pick-Up Service: This service provides means hereby P.A.B.X. parties whose duties frequently ke them away from their desks to other parts of the epartment but within hearing distance of their tele- none bell, may answer calls to their telephone by aling from any other telephone, a specially assigned umber. For example, if Mr. A should leave his desk consult with Mr, B, he can answer telephone calls his desk merely by dialing his pick up number on r. B's telephone. Any number of lines in a P.A.B.X ay be equipped for Pick-Up service but each service stallation is separate and distinct from the others.

55 Night Answering and Transferring Service: ight trunk service is normally provided on P.A.B. 's by extending the trunks to certain specified tele- hones. If often happens, however, that individuals re not located at fixed points. In these cases, it is esirable to have means whereby watchmen or other dividuals can answer incoming trunk calls no mat- r where they may be about the plant.

ight Answering and Transfer service provides these cilities. It consists of a number of trunk signals nveniently distributed about the premises so that ey can be heard or seen by anyone on duty. To nswer incoming trunk calls, the individual steps to e nearest telephone, dials a pre-arranged night nswering number and is immediately connected to e calling party.

he finds that the call is for someone else, he steps another telephone and by dialing the wanted party's umber (or by calling him by means of code call gnals - see Code Call Service Sec. 128) notifies m that there is a call for him. The second party en dials a second associated night-answering num- er and is placed across the trunk. The first party etires from the connection by restoring his handset.

56 Power: The power facilities of a telephone ex- hange must provide not only direct current for the ransmitter, relays, and switches but also must rnish a variety of alternating currents used in nging and signaling. Most important, however, is e equipment furnishing direct current from which e exchange, as a whole, operates.

ommercial alternating current is ordinarily the imary source of power, for the reason that it is nverted into direct current of the proper voltage by itable rectifiers or motor-generator sets. As a otection against commercial power failure, storage tteries charged from the motor-generator or rect- er are provided. In emergencies, the exchange can operate from the batteries for periods of several hours. Often a stand-by engine generator is provided in order that the exchange may be independent of power failures.

Automatic central-office equipment is designed to operate between such limits as 44 to 53 volts which is considered usually to be the 48-volt range (24 cell battery). In the interests of uniform operation, it is desirable that the exchange voltage be held as close to the chosen value (48-volts) as possible even though there is a definite range of voltages over which equipment will operate.

156 (a) The Battery and Voltage Control: Fluctuations in commercial line voltages to the charger and changes in demand for 48-volt direct current cause voltage variations. Furthermore, charging a battery raises its voltage; discharging decreases its voltage.

Years ago, two sets of batteries were maintained in order that one might undergo charge while the other was discharging. Since the life of a battery depends upon the number of times it is charged and discharged, this "cycling," as it is called, proved to be an expensive method. Today only one battery is employed; a charger is connected to this battery for such periods of time as are necessary to maintain it in a fully charged state not only that there may be a maximum supply of reserve energy but that the battery is not cycled; that is, not alternately charged and discharged. Any current demand put upon a battery undergoing charge will be drawn from the charger up to its capacity. Any demands beyond the capacity of the charger will be supplied directly from the battery. A battery is said to be floated when the charger connected across it is carrying all or part of the load.

In order that a charger may push current into a battery, it must have a higher voltage than the battery. The greater this excess voltage, the higher will be the charging rate. A 24-cell battery will have a voltage of 49.2; on charge at an 8-hour rate, this voltage will rise to 62.4. The 8-hour rate is such that the battery if empty would be completely charged in 8 hours. Often such a rise in voltage is too great for the operating range of the equipment.

156 (b) End Cells: To reduce the rise of voltage on charge, the charging rate may be reduced, and say, two of the cells removed from the circuit. These two cells, called "end cells" because of their position in the battery, will be restored to the discharge circuit when the voltage falls, as upon completion of the charging.

156 (c) Counter-Cells: A second method is to place one or two counter-electromotive force (C.E.M.F) cells in the discharge circuit, during the charging period. Such cells, will reduce the output voltage to the exchange equipment. A counter-cell acts as a regular battery cell connected backward to oppose and cancel an equal number of regular cells. The

counter-cell has little actual capacity beyond its ability to maintain an opposing potential.

156 (d) Full-Float Operation: If, in place of the rapid charging described above, a battery is maintained on a full-float basis, the voltage for 24 cells will be 51.6 volts; i.e., 2.15 volts per cell. This is 0.1 volt per cell above the normal voltage and will serve to keep the battery fully charged. Counter cells are not ordinarily employed under full-float operation as the battery voltage remains quite constant. However, in some full-float systems, they are employed as a means of holding the voltage normal in the event of a power failure.

156 (e) High-and-Low-Voltage Controlled Charging: High-and-Low-Voltage relays may be employed to stop and start the charger as required to maintain the battery in approximately fully charged condition.

156 (f) Battery Eliminators: Small exchanges especially P.A.X's in areas of extremely reliable power supply, sometimes employ battery eliminators. These are similar in principle to battery chargers.

156 (g) Functions of the Battery: Batteries have, however, more than the single function of providing a reserve supply of power. They provide a supply of constant voltage and in addition have a filtering action on the various circuit noises. Lead acid batteries are the type customarily employed in telephone practice.

156 (h) For article on the prevention of generator noise, see AT (Smith) 9-21; on automatic voltage regulation, see AT (Clapham) 5-20: on full float operation, see AT (Diehl) 7-26, AT 7-27 and AT (Cadden ) 7-31; also A.E.Co. Bul. 812.

157 Preliminary Impulses: All Automatic and machine switching systems must guard against what are termed "preliminary impulses." When a subscriber removes his receiver it is quite possible that he may cause the switch hook to flutter, thus opening the line circuit and causing an operation of the first selector similar to that which takes place when the figure "1" is dialed.

Should a preliminary impulse occur it is quite evident that the calling subscriber will fail to reach the party called. It is common practice to refrain from assigning subscribers' numbers commencing with the digit "1", for if this assignment were made a wrong number call would be extended to that group of lines each time a preliminary impulse occurred. The first level of the first selectors is usually assigned to special service. When this is done, and a preliminary impulse occurs, the worst that can happen is that the calling party may reach some special service operator. This is regrettable, but is to be preferred to having the call needlessly annoy another subscriber.

A special arrangement of selectors may be used which effectively guards against wrong numbers as the result of preliminary impulses. Referring to Fig. 1, it will be seen that a group of trunks extend from the

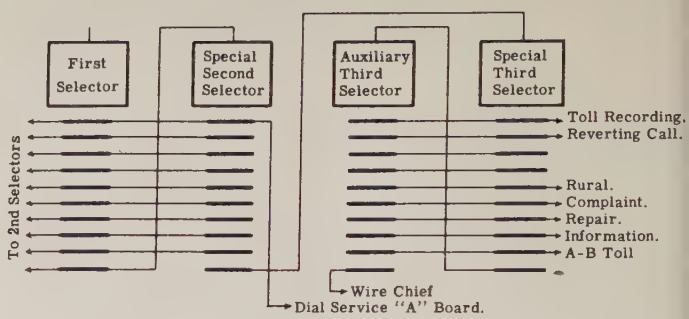



Fig. 1 - Special Trunking to Obviate Preliminary Impulses.

first level of the first selectors to special second selectors. All levels of the special second selectors, except the first, are multipled with the corresponding levels of the first selectors. Trunks from the first level of the special second selectors lead to special third selectors, and trunks from the first level of the special third selectors are extended to auxiliary third selectors. All levels of the auxiliary third selectors, except the first level, are multipled with the corresponding levels of the special third selectors.

If a preliminary impulse occurs the calling line is connected through the first level of a first selector to a special second selector. If the call is for a subscriber or a zero operator the first digit dialed will be some figure other than a "1." And this digit will select, at the special second selector, a level which is multipled to the corresponding level at the first selector, and the call will be completed in the usual manner.

If the call is for an operator other than a zero operator the first two digits dialed will each be "1." On such a call, should a preliminary impulse occur, the first digit dialed will cause the special second selector to extend the connection through its first level to a special third selector. The second digit dialed will cause the special third selector to extend the connection through its first level to an auxiliary third selector. The third digit dialed will be some figure other than "1," and this digit will select, at the auxiliary third selector, a level which is multipled to the corresponding level at the special third selectors, whereupon the call will be completed to the operator in the usual manner.

For further discussion see AT (Clapham) 4-20, and for article on special services see AT (Clapham) 12-19.

158 Push Button Ringing: In this connector, two relays are used to feed battery to the calling line; the first relay (the line relay) is connected to battery, and the second (ring control) relay is connected to ground. A push button at the telephone is so connected that it grounds the negative side of the line when operated. After the completion of the dialing, the calling subscriber operates the push button to signal the called party, thereby shunting out the ring control relay

which falls away and causes generator to be impressed on the called line.

159 The R.C.X: The Strowger Remote Controlled Exchange is a new type of automatic switchboard which is operated from a distant exchange over a single control circuit, instead of from dials on the subscribers telephones. The operator has practically the same supervision and control of the local lines as she would have if she were seated at a manual magneto switchboard where these lines terminate. The R.C.X. simply replaces the old switchboard without requiring any change whatever in the subscribers lines, stations, or service.

For further discussion see AT (Engh) 6-33.

160 Radio Interference: Saunders, writing in AT-2-31, said: "generally speaking, interference from telephone central offices has not been serious. Only a comparitively few plants have been the cause of complaint. These special cases have been found to involve some extraordinary circumstances which were exceptionally favorable to carrying radio frequencies out over the lines."

161 The Release Link: It was necessary to use a release link when side switches were used in order to hold the sideswitch in its home position after the switch had released and until the completion of the vertical digit on the next call. The elimination of the sideswitch made the release link of less importance but still it was retained because of the possibility of a switch being reseized while it was in the process of releasing. If it were reseized, the operation of the pulsing relay would open the release circuits and if it were not for the release link, the switch would not completely release. The result would be the calling of a wrong number.

This trouble was brought about, (1) due to line-switches, and (2) due to the selectors being the type which searched for the absence of ground.

Since line finders and battery searching selectors are now being used extensively, the need for the release link is becoming of still less importance. If the finder distributor is so designed that it cannot seize a finder until both the finder and its associated selector have released, the finders and the first selectors require no release links. If subsequent selectors and connectors are of the type which hold battery off the C conductor until they release, then these switches need no release links because they are automatically made busy.

Like Flanagan's train, release links have been "off again, on again" numerous times. At this writing it appears, they should be on, but no one seems to know just why.

There is a general tendency to remove release links on new designs which use finders and battery searching selectors.

For a historical treatment of the development of the release circuit see (AT Martin) 1-19.

162 Restricted Service: Frequently in a network of C.A.X's, it is desirable to restrict all subscribers or a group of subscribers from connecting with certain trunks such as toll lines which are accessible to the operator. Such facilities are available in some C.A.X's. A similar feature is sometimes called "Discriminating Service."

163 Reverting Calls: See Sec. 218 (c).

164 The Routiner: The following quotation is taken from the first (1917) edition of this text:

> "In the maintenance of their automatic switchboards the various operating companies are coming more and more to the adoption of standard adjustments and of routine inspections. This is merely another illustration of that great growth of the last few years which has resulted in the division of labor and the specialization of the employe.
>
> While it is beyond the scope of this work to discuss the details of standard adjustments and routine inspections, still we will be repaid to devote one chapter to what is perhaps the most important of the routine inspections. Reference is had to the testing of the connector switches. It would be well at this time to refer to the first chapter and review the seven functions of the Connector Switch.
>
> Before routine inspections were adopted there was no set way of proceeding to test out a connector switch. Each switchman had his own idea as to how it should be done, and as a result some of the seven functions were likely to be overlooked. Mr. Roy Gould, while in charge of the plant at Lansing, Mich., first conceived the idea of developing a testing circuit which would standardize the operations in testing a connector."

It has been a long step from Gould to Kessler, and it is regrettable that the space does not permit a discussion of the modern routiner. For further information see AT (Clapham) 7-20, and STJ (Kessler) 12-33.

165 Service Observation: Service observation is generally recognized as an invaluable aid in the operation of a telephone office or system. It offers a convenient method of ascertaining the quality of service which a telephone organization is offering to the public. Systematic service observation also provides valuable information for (1) Plant up-keep, and (2) Plant Growth, including personnel, services, and equipment. For detailed information on service observation, see A.E.Co. Bul. 365.

Service observation consists simply of observing a certain number of calls of the regular traffic passing through a central office. The application of the Multiple Pen Recorder to service observation presents unusual advantages. The Recorder is very useful as a means of augmenting the service rendered by the regular service observation equipment, or it may be used by itself to implement service observing routines. It can be connected to individual subscribers' lines, to groups of individual lines, or to a group of trunks as in the case of a P.A.B.X.

The high operating speed of the Multiple Pen Recorder makes it possible to secure all of the following information on subscribers' lines in automatic central offices.

| On Outgoing Calls | On Incoming Calls |
|---|---|
| Number Dialed | Ringing Code |
| Dialing Time | (when used) |
| Answering Time | Answering Time |
| Talking Time | Talking Time |
| Holding Time | Holding Time |

For further discussion see A.E.Co. Bul. 368

166 Simplex Dialing: Here grounded dial pulses pass over the + and - line in parallel, thru the primary of a repeating coil and from its center tap to a single wound line relay. See composite dialing Sec. 122(b).

For further information see STJ (Grandstaff) 6-40.

167 Slugless Pulsing: In most switch circuits, it is customary to provide copper "sleeves" or "slugs" on the coils of relays required to remain operated on the intermittent pulses from the line relay (usually the B, C, and E relays). In the circuit under discussion, the copper sleeve or slug is omitted from the B relay and the relay is held operated during impulsing by the "slugging" effect of short circuiting the coil winding during the "off" period of the impulse.

Prior to the advent of short lever (1:1 ratio) armature, and the widespread use of sleeve coils, it was necessary to provide an extremely weak adjustment and to omit the residual setting on the B relays in particular. The purpose of slugless pulsing was to permit the use of heavier adjustments on the relays and permit the use of residual settings so as to obtain more uniform release-time characteristics from the relay, and to increase the operating range of the switch. When the short lever armature was perfected, it became possible to obtain satisfactory characteristics from the B relay without restoring to the "slugless" pulsing arrangements and the increased operating range obtainable from this method was no longer sufficient to justify the more expensive impulsing relay and circuit complications necessary in order to apply this arrangement to connectors having minor switches.

168 Splash Ring: If the ringing interrupter applies ringing current for one second our of each five seconds, and if a line is seized just at the finish of the ringing period, the call must wait four seconds before the first ringing period is applied. This results in four seconds waiting time and four seconds more holding time for the switches.

Euopean practice attempted to correct this by sending a splash ring immediately upon seizure of the line, regardless of the position of the ringing interrupter.

In American practice the results were not satisfactory. The splash ring might just precede the regular ring and result in an abnormally long ringing period. The splash ring might result in only a short pause before the start of the regular ring and this would sound like a two-ring code. The splash ring could not be used with code ringing and it was a hardship on harmonic ringing. The splash ring increased initial cost and maintenance cost.

169 Supervisory Equipment: Automatic exchanges, large and small, are provided with signal equipment for giving alarms should any non-standard conditions arise in the exchange. The alarm, audible and visual, will indicate the type of condition and, in larger exchanges, the general location of the fault.

In C.A.X's, the alarm usually consists of a buzzer to attract the attention of anyone in the building plus colored lights on the power panel indicating the particular condition; i.e., release alarm, finder start failure, charge alarm, ringing machine failure, fuse alarm, and permanent lines locked out. Since smaller exchanges are usually unattended, provision is made for an alarm sender which will notify the nearest toll operator that a non-standard condition exists. The operator may then dial the alarm checking number and receive a distinctive tone which will identify the condition existing. From a typical exchange, the operator will hear interrupted generator indicating "no trouble"; busy tone for a minor alarm (connector release failure); dial tone for a "permanent;" no tone, for an emergency (major fuse blown, charge alarm, ringing machine, or finder start). The operation of the various alarm circuits is under the control of relays mounted on the supervisory panel and on the connector, selector, and line equipment units.

The exact supervisory scheme is dependent on the floor plan, size of the exchange, and type of equipment. In the larger offices consisting of many bays of rack mounted equipment, a signal scheme is employed which will guide the attendant to the particular group of frames and then to the particular shelf on which the trouble is located.

When an abnormal condition develops, an audible alarm sounds and a signal lamp will light on a ceiling panel in view of the switchman. This lamp will indicate by its color and designation the type of alarm and the group of frames in which the trouble is located. Thus, the condition may have occurred in the line-finders, 1st selectors, 2nd selectors, connectors in a particular thousand group, and so on. The switchman has only to go to the indicated frame group where

second lamp will identify the shelf on which trouble is occurred. A visual inspection of that shelf will cate the particular switch causing the alarm.

here are two types of abnormal conditions which ay be encountered. The first is abnormal as soon the condition arises - for example, the blowing of fuse on any one of the power panels; such an occurence causes the immediate operation of the alarm quipment. The second is a normal condition which ecomes abnormal only after an appreciable time terval, such as the failure of a connector to release ven though the release magnet is energized. In this tter case, the alarm equipment should not operate ntil after the normal releasing time of the switch as elapsed.

ach of the lineswitch (or finder), connector and selctor groups has associated with it a group of relays he function of which is to delay the operation of the larm equipment on the second type of abnormal onditions. The interval of delay is controlled by vo release-time control relays which are operated lternately by the ringing interrupter equipment.

69 (a) For further discussion see AT (Clapham) -10, AT (Diehl) 9-22, AT (Saunders) 9-31 and A.E. o. Bul. 812.

70 Time Service: Strowger equipment affords an utomatic device which will function to give a callng subscriber the time of day. It is unique in that he subscriber is under the impression that he is stening to a grandfathers clock strike out the hours nd minutes.

subscriber, upon calling the time number, will hear nmediately the ticking of a master clock located in he telephone building. After the ticking ceases the lock will slowly strike the hour on a deep toned gong. he minutes will next be sounded and will be struck two distinct groups. A medium pitched gong at oderate speed will spell off the "two," three" or four" ( representing twenty, thirty or forty as the ase may be), in order to distinguish it from the inal group which will be struck at a more rapid rate n a high pitched gong.

or further discussion see AT-9-30 and AT 5-31.

71 Tones: There are three tones universally in se today. These are: dial tone, to indicate that the witching equipment is ready to receive dial impulses; ring-back tone, to indicate that the called arty is being rung; and busy tone, to indicate that he called line is busy. Special tones such as "tick" nd "all-trunks-busy" are also employed at times. he tones above are especially for the subscriber.

hen the operator at an attended exchange answers a all, she may receive certain tones such as "paytation" or "class-of-service" tones which inform er of the type of service to be rendered or the xtent of service to which the subscriber is entitled.

172 Traffic Meters: Automatic meters may be associated with the switches so that both the total traffic and its distribution can exactly be dertermined

Any group of switches may be provided with meters for obtaining the following records: (1) The total number of calls originated; (2) the number of times that all of the trunks become busy; and (3) the number of delayed and wrong connections due to all the trunks being busy.

173 Traffic Studies: Telephone traffic is subject to wide variations due to numerous causes. Some of these variations are of a temporary nature, while others are the result of changed conditions and are permanent. Temporary variations generally happen so that the peaks of one group of trunks are attended by depressions in another group of trunks. The variations which assume a permanent character usually are brought about gradually by a slow increase in total traffic carried, or by shifting traffic loads. Furthermore, these natural variations may be augmented by unbalanced assignments. In any event, the need for constant and thorough supervision of the traffic handled by an office or an exchange will be readily appreciated. Only by such supervision will a smooth running system be assured, and one in which all of the equipment will be used to the best economical advantage.

Systematic observation of the traffic loads carried by an office or an exchange system will provide invaluable data which not only will indicate when additions are needed, but will show exactly how much additional equipment is required. Definite traffic data of this nature is absolutely essential when a conversion from manual to automatic operation of an office is being considered.

The Multiple Pen Recorder provides means for making complete traffic surveys of both automatic and manual offices. Every desired traffic study, from simple plug counts to involved load-distribution and lost call studies on graded selector switch multiples, may be readily conducted with the Recorder and its associated equipment.

It may be mentioned here that there is no conflict between the well-known traffic tables (Molina's, Erlangs, etc.) and the Multiple Pen Recorder. Each is fully reliable and has its own field of usage. From the traffic tables, the number of trunks required may be ascertained after traffic data has been secured. The Pen Recorder, in an entirely different field of endeavor, makes actual traffic observations and indicates directly whether there are too few or too many trunks in a given group, and whether the traffic is balanced between groups.

Thus, traffic tables are used when a telephone office is first engineered. From the tables the number of switches required for the various ranks is estimated from whatever traffic data is available. From that point on, it remains for the Multiple Pen Recorder to give a continuous picture of the actual traffic

handled by the different ranks of switches. Also, the Recorder obtains the essential data required for additions and conversions. In other words, the Multiple Pen Recorder finds its niche in the daily operation of a telephone system, by direct observation of traffic conditions.

For further information see A.E.Co. Bul. 368.

174 Watchmen's Service: P.A.B.X. watchmen's service is available in two types - a simple Recording Type and a Combined Recording and Supervising Type.

174 (a) P.A.B.X. Recording Type service permits any or all P.A.B.X. stations to be watchmen's reporting stations. If a reporting station is desired at a point where it is not considered advisable to have a telephone, a wall jack can be installed and the watchman can plug in with a hand telephone carried for that purpose. To make a report he needs only to dial an assigned number and listen for a special tone. This tone signifies that a printed record has been made on a Multiple Time Recorder showing the time and source of the call or report. The Multiple Time Recorder is a secondary clock with a motor driven mechanism that prints a plainly legible record on a moving band of paper. It has a capacity of 59 reporting stations and is equipped with a locking cover to prevent tampering. When desired, it can be wired to record each time the cover is opened.

174 (b) Combined Recording and Supervisory Service includes all the features of Recording Service plus a supervisory cabinet containing a lamp for each recording station together with route keys, buzzer, alarm bell and a telephone. When a watchman reports, a corresponding station lamp lights, a buzzer sounds and a pilot lamp lights. The supervisor may throw a key and talk with the watchman or he can call him at any station by merely operating a key. The pilot lamp and buzzer operate only while a report is being made but the station lamp remains lighted until the report is made from the next station on the route. If the watchman fails to report within a prescribed time, or if he reports in the wrong order, a visual indication is set up in the supervisor's cabinet and an alarm sounds. If such errors are not corrected within a prescribed time, a second alarm may be sent to an outside point such as a police station.

175 Connectors Pecuiliar to P.A.B.X's: When a P.A.B.X. is connected to a manual exchange a trunk-hunting connector such as described in Sec. 215 (b) could be used to give access to a group of trunks leading to the public exchange. This would require the dialing of two digits.

A "one digit" connector functions similarly, but requires the dialing of only a single digit to reach a group of trunks (there can be only one group on a given level).

In this connection mention may be made of a very peculiar switch, when "00" is dialed that connector stops on the first idle trunk in the "0" level.

When the P.A.B.X. is connected to an automatic office, the problem is not as simple, for in this case, the calling party must be able to dial into the public office.

175 (a) Impulse Repeating on Trunking Level: The first series of impulses causes this connector to elevate its wipers to the trunk-hunting level, after which it automatically rotates in on the level in search of an idle trunk. When an idle trunk is reached, the trunk loop to the switch ahead is closed through an appropriate impedance. Further dialing results in the opening and closing of the trunk loop which causes the switches ahead to complete the desired connection.

175 (b) Switching Through on Trunking Level: The first series of impulses causes this connector to elevate its wipers to the trunk-hunting level, after which it automatically rotates in on the level in search of an idle trunk. When an idle trunk is reached, the calling line is cleared of attachments and switched through to the seized trunk; the release relay of this switch remaining operated until the switch ahead returns holding ground to hold this and the preceding switches.

Connector of this type are sometimes called "Selector-Connectors." Do not confuse with the switch called a "Selector" in Sec. 215 (c).

176 Call Indicator Equipment: It is desirable that an Automatic station shall obtain connections with any other station in the same local area by the simple method of dialing the call number of the desired telephone, regardless of whether or not all the stations in the area are Automatic. In order to give this service, certain operators' positions in the manual office may be equipped with call indicator equipment.

A call indicator has as many groups of numbers from 0 to 9 as there are digits in the directory numbers, see Fig. 4 Sec. 215 (e). Normally the figures appear very faintly. A lamp is placed beneath each figure which, when lighted, displays that figure quite prominently. When an Automatic subscriber dials a telephone number, assigned to a telephone in a manual office, the first digit causes the first selector to extend the connection to that particular office. The succeeding digits each operate a register. (Several sets of which are associated with each call indicator). When all digits have been registered, a set up pilot lamp on the operators key board is lighted, and at the same time the number set up on this particular set of registers is displayed by the call indicator lamps. At the same time an assignment lamp associated with the calling trunk lights and thus identifies the cord to be used. The operator then inserts the plug associated with that cord into the multiple jack of the line indicated by the number displayed upon the call indicator. Whereupon this particular set of registers is

leased and the call indicator is left free to handle ner calls.

lls from the manual office to Automatic subscri-rs are usually handled by providing dials at the A sitions of the manual switch board. See Sec. 213 (d).

or further information see AT 5-25. Pg. 41.

7. The Line Switch: McMeen and Miller in their 12 edition said, "The Automatic system is one of e most astonishing developments of human ingenu-y. The workers in this development are worthy of rticular notice. That the system should bear the me of Strowger gives too great prominence to his ork and too little to that of the engineers of the utomatic Electric Company under the leadership of lexander E. Keith."

any type of telephone system, some sort of an elec-ical device associated with each line is required to lentify, or mark, the individual line originating or eceiving a call. In the magneto manual system, this paratus is a drop, usually combined with a spring ck; and in the central battery manual system it is line and cut-off relay, the former controlling a lamp attract the operator's attention when a call is riginated.

earlier Strowger systems, individual line selec-rs were employed for systems over 100 lines, and dividual line connectors were used for systems of 00 lines or less. The time-efficiency of the sub-criber's telephone line and, likewise, the switching quipment associated therewith is very low; there-ore, it is more economical, both from a viewpoint of itial cost and maintenance, to provide individual ine equipment of more simple design and of few nctions. In the modern Strowger systems (other an finder systems), this equipment takes the form f a non-numerical switching device associated with ach subscriber's line. The non-numerical switching evice may be either; (1) a Keith (plunger) line witch, or (2) a rotary line switch.

78. The Keith Line Switch: This is a simple mech-nism which automatically connects the associated elephone line to any one of a number of trunks lead-ng to Strowger "numerical" switches, when the Monophone handset is removed from the telephone reparatory to dialing a number. Selection is "non-umerical" since the lineswitch functions prior to ialing. The numerical capacity of the telephone sys-em will determine whether the trunk seized will erminate at a selector or connector switch. A "nu-nerical" switch may be defined as a switching mech-nism in which dialing impulses control certain of ts functions.

Plunger lineswitches are grouped under the control f master-switches. Each lineswitch group, generally consisting of from twenty-five to one-hundred line-switches per master-switch, has access to a maxi-num of ten trunks.

As shown in Fig. 1, the trunks leading to ten trunking switches have been multipled thru four Keith line switch banks. The line switch consists of a magnet

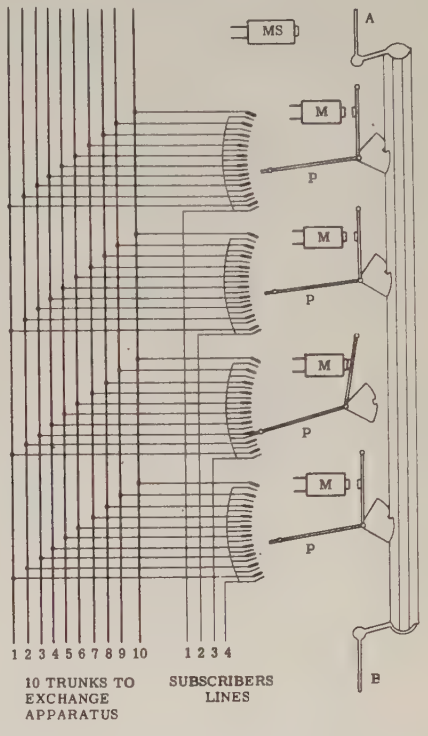



Fig. 1 - Principle of Plunger Line Switch.

M, and a plunger P, the head or wing of this plunger is slotted so that it may engage a projecting edge of the plunger guide shaft. The shaft is pivoted at the points A and B and is capable of an oscillatory motion thru about forty degrees, under the control of the master switch M.S. This motion of the shaft causes the plungers of the various line switches to swing back and forth in front of the line switch banks. The master switch so controls the shaft that it will only come to rest opposite an idle trunk. Let us assume that the shaft is holding all the plungers opposite the thrid trunk. If a subscriber removes his receiver, the corresponding line switch will "plunge in" and extend the connection to the trunking equipment associated with the third trunk. The line switch which plunged in is now free of the shaft, see the third switch from the top. The master switch immediately, by means of the shaft, moves the remaining line switches opposite an idle trunk, thus we have what is termed "preselection of trunks."

If the calling subscriber now restores his receiver, the associated line switch will "come out" of the bank, but the slot in the wing of the plunger will not engage the shaft at this time. This particular line switch, therefore, will remain opposite trunk number three until such time as the shaft again swings in front of that trunk and "picks it up". It is essential that a line switch must not plunge in during the time that the master switch is seeking an idle trunk, for if it did, the calling party would get in on a busy line. This is prevented by what is termed the "open main" battery feed.

The line switch bank consists of a set of springs for each trunk, as shown in Fig. 1 below. As the standard bank accommodates ten trunks it will therefore contain eighty springs. When a plunger enters the bank, it causes the curved springs to first move over against the straight springs and then to partially straighten out, thus causing a rubbing effect which produces a perfect electrical contact.

178 (a) Line Switch Mechanism: The Keith line switch, Fig. 1 consists of a plunger, a relay, and a

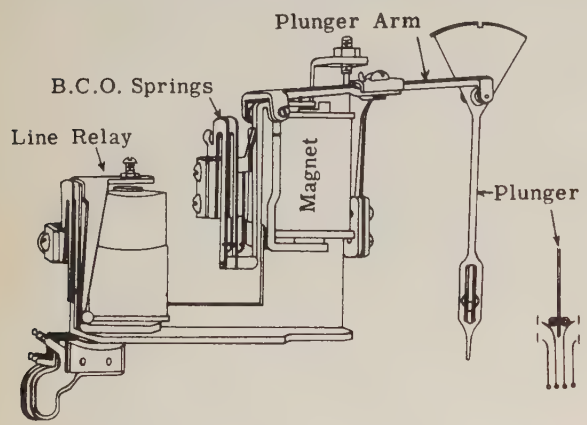



Fig. 1 - Line Switch Mechanism.

magnet, all mounted on a soft iron base. The plunger is mounted on a pin at the end of the plunger arm, in such a manner that it is free to rotate thru an angle of about forty degrees. The plunger may be moved in a longitudinal direction by the plunger arm. Near the tip of the plunger are mounted two hard rubber rollers which serve to actuate the movable springs of the line switch bank.

The function of the magnet is two fold, namely, to operate the plunger arm and thus cause the line switch to "plunge in," and to operate the small armature which controls the bridge cut-off springs. The magnet is double wound. One winding, called the pull down winding, is low in resistance and when energized operates both the plunger arm and the B.C.O. springs. The other winding when energized alone, operates the B.C.O. springs only. It is, however, sufficiently strong to maintain the plunger arm after it has been operated by the low resistance winding.

178 (b) Master Switch Mechanism: The master switch, see Fig. 2, consists of a locking segment by means of which the master switch shaft is held in the proper position opposite the various trunks; a solenoid which is capable of moving the shaft from left to right; a U-shaped spring which is capable of moving the shaft from right to left; a governor to control the speed of movement; several relays and two tripping arms which serve to control the operation of the master switch. With each master switch is associated a master switch bank which consists of ten pairs of contacts. In structure this bank is similar to a single level of a connector line bank.

178 (c) Line Switch Boards: The capacity of a line switch bank is ten trunks, and in theory a given group of trunks will be multipled thru enough line switch banks to give it the proper load. One hundred line switches are mounted on a board. Fifty switches are mounted on the left hand shelf and fifty switches on the right hand shelf. Each shelf is in turn divided into two parts, twenty-five switches are mounted on the upper section and twenty-five on the lower section. At the top of each section may be mounted a master switch which, by means of its associated shaft, controls each of the line switches in the section so that the plungers of idle line switches are at all times standing opposite an idle trunk.

The twenty-five line switch banks associated with the twenty-five switches of a certain section are multipled vertically. That is, trunk number one, for instance, will appear as the left hand set of contacts in each of the twenty-five line switch banks. The ten trunks are taken from the last bank in the section, thru a hand-made cable, to terminals which are mounted at the top of the line switch board.

If the traffic from twenty-five line switches is not sufficient to properly load ten trunks, it is customary to multiple, at the terminal, the banks of an upper and a lower section, thus routing the traffic from fifty switches to a group of ten trunks. Since one group of ten trunks now serve the two sections, it will be necessary to remove the upper master switch, attaching the upper shaft to the lower master switch.

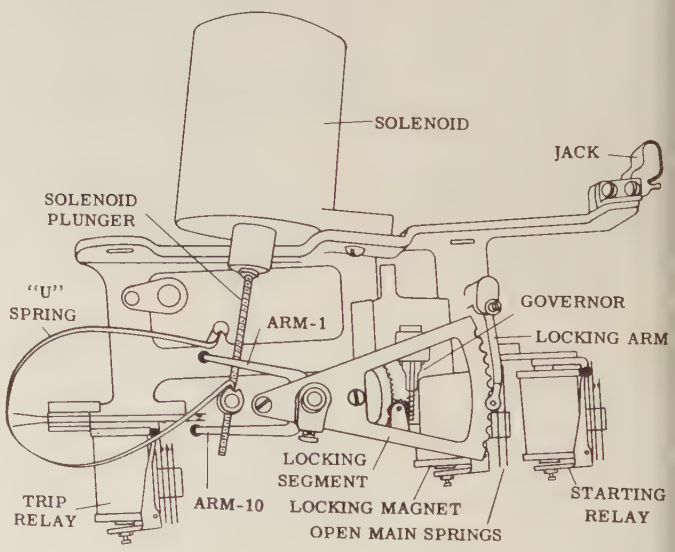



Fig. 2 - Master Switch Mechanism.

If the traffic from fifty line switches is not sufficient to properly load ten trunks, it is customary to multiple, at the terminal, the banks of the upper and lower sections of one shelf with, we will say, the upper section of an adjacent shelf. Thus routing the traffic from seventy-five switches to a group of ten trunks. Since one group of ten trunks now serve the three sections it will be necessary to remove the master switch associated with the upper section of the adjacent shelf, attaching the shaft, by means of a

ıecting link, to the master switch controlling the f to which this section has been multipled. The rth section of this board will be multipled with a f of an adjacent board.

ıe traffic from seventy-five line switches is not icient to properly load ten trunks it is customary ıultiple, at the terminal, the banks of the four sec- s of one board. Thus routing the traffic from one dred switches to a group of ten trunks. Since one ıp of ten trunks now serve the four sections it will ıecessary to remove all but one master switch. four shafts will be controlled, thru the use of con- ting links, by one master switch.

s possible, altho not customary, to continue mul- ing sections if the traffic be exceedingly light. If traffic from twenty-five line switches is more ı a group of ten trunks can carry, there is no con- ient way to split the multiple. The proper proce- e is to remove enough of the line switches to bring traffic within the carrying capacity of ten trunks.

n a subscriber's I.D.F. is not used, one hundred switches (two shelves) are mounted on one side line switch board. The connectors associated ı this particular group of lines are mounted on the r side of the same board. When a subscriber's F. is used, one hundred line switches are mounted he front and one hundred line switches on the rear ach line switch board. In either case both the in- ing and outgoing cables terminate upon terminals the top of the board. A slate panel is provided to ommodate fuses, signal relays, lamps, etc.

a discussion of the various types of Keith line tch (3-wire, single coil, non-aligning and align- see Sec. 278.

. The Rotary Line Switch: The rotary lineswitch ometimes used in Strowger systems as individual equipment instead of the Keith (plunger) line- tch. For this purpose it is particularly well pted for certain traffic and service conditions.

rotary lineswitch is a single-motion (rotary) n-numerical" switching device consisting of a relay, a cut-off relay and a rotary mechanism ilar to that described in Sec. 208.

otary lineswitch is associated with each telephone and, in operation, is independent of all other switches; therefore it requires no distributor, ter or master switch. This lineswitch auto- ically connects the associated telephone line, at time of the initiation of a call, to an idle trunk minating in a connector (100-line system) or a ector (in a larger system).

h respect to circuit operation, rotary lineswitches divided into two general types; namely, the "hom- " type and the "non-homing" type.

oming type rotary lineswitch is one which nor- lly rests in an off-trunk position. At the termina- tion of a connection, the wipers are caused to rotate to this "home" position (generally the first position of bank contacts). The homing type lineswitch is "post-selecting." By this is meant that the selection of the idle trunk occurs after the call is initiated.

This type of rotary lineswitch is used where a "graded" trunk arrangement is employed, as selection of trunks commence at the home (first) position, thus permitting a few individual trunks to be used. Graded multiple is a term applied to a method of trunking whereby a small number of trunks of a group are individual to a number of lines, and the remaining trunks are common to a number of groups of lines.

In the non-homing type lineswitch, the position of the selecting wipers does not depend on the condition of the trunk (whether idle or engaged) but they remain in the position of the trunk previously used by them. Another call from the same line will engage the same trunk, if idle; or, in case the trunk is occupied by another lineswitch, the wipers will be rotated to the next idle trunk. While the non-homing type rotary lineswitch is theoretically post-selecting, in practice the lineswitch will engage the trunk with which its wipers are in contact in a large percentage of the initiated calls.

The non-homing type rotary lineswitch is available in four different trunk capacities; namely, 11, 16, 25, and 50 trunks; and commonly are referred to as the 11-point, the 16-point, the 25-point, and the 50-point rotary lineswitches. The latter has only been used for very special conditions. Where the 25-point rotary lineswitch is used as individual line equipment (primary lineswitches), the outgoing trunks generally terminate directly in connectors or selectors, since a common group of twenty-five trunks is very efficient with respect to the traffic which can be handled by the group during the busy periods.

For further discussion of the rotary line switch, see Sec. 279 and A.E.Co. Bul. 806.

180. Secondary Line Switches: In the larger Strowger systems, secondary lineswitches are generally employed to combine the traffic from a number of primary groups of subscribers' line switches and direct it to a common group of numerical switches capable of handling this combined traffic. With this arrangement, each trunk leading to a numerical switch is equally accessible from any subscriber's line served by the combined group of trunks.

Experience has shown that small trunk groups are not capable of handling as many calls per trunk as a large group. This is for the reason that a large number of telephones will offer a more stabilized traffic load than will a smaller number of lines. The maximum traffic delivered to a large group will be the same as the combined traffic from all the small groups serving it, but the combining of the small groups into a large group has the advantage that the

traffic peaks of the small groups do not occur at the same time.

The application of secondary line switches takes advantage of this lack of uniformity (which is characteristic of telephone traffic) to reduce the number of selectors required to handle a given volume of traffic. This is accomplished through a comprehensive distribution system introduced in the wiring between the secondary lineswitches and the subscribers' line equipment.

The purpose of the secondary line switch is, therefore, similar to that of the primary line switch in that is serves to reduce the number of selectors thru the addition of less expensive line switches; hence, the object of secondary trunking is wholly economic. Local secondary line switches are interposed between the subscribers' line equipment (primary line switches) and the first selectors.

180 (a) Method of Trunking to Secondary Line Switches: The basic features of secondary line switch trunking are illustrated in Fig. 1. This figure shows

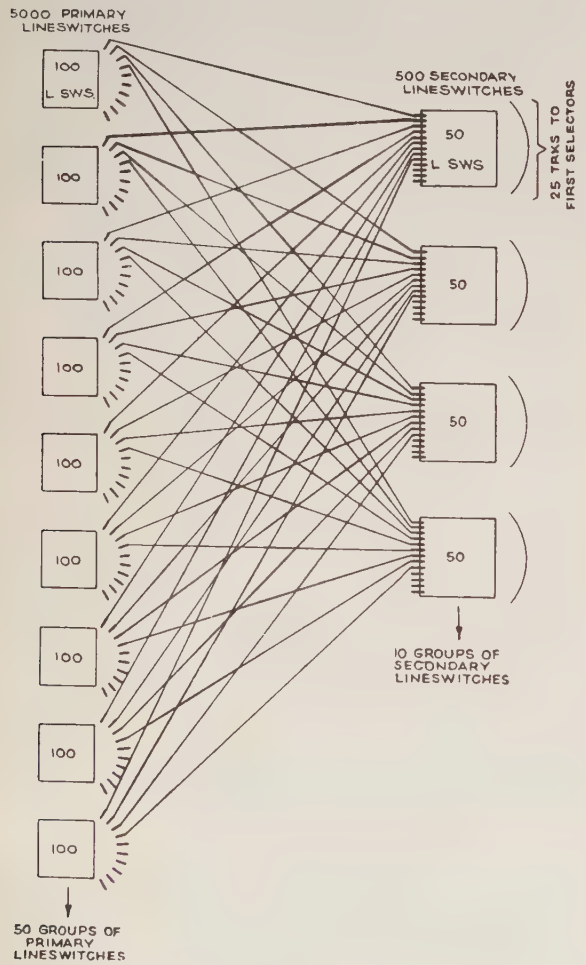



Fig. 1 - Trunking From Primary to Secondary Line Switches

fifty groups of primary lineswitches and ten groups of secondary lineswitches. Each primary group consists of 100 lines, although in practice the number of line switches per group is dependent on the average traffic per line and will differ in individual cases.

Each primary group shown in the figure has access to ten trunks; hence there is a total of 500 trunks from the primary line switch groups. This assumption of ten trunks per primary lineswitch group is based on the use of plunger type or 10-point rotary type line switches. It is understood that a greater or lesser number of trunks may be employed in individual cases.

The 500 assumed primary trunks, instead of being directly connected to first selectors, terminate in secondary lineswitches - one for each trunk. These secondary line switches are divided into ten groups of fifty secondary line switches each.

In the example, it is assumed that each secondary line switch group has access to twenty-five trunks terminating in first selectors, or a total of 250 selector trunks.

Through a comprehensive cross-connecting scheme the outgoing trunks from the primary line switches are so distributed that each of the ten trunks in one primary line switch group terminates in a different secondary group. For simplicity, Fig. 1 shows these trunks connected in a progressive way. In practice however, these cross-connections are in accordance with a system of enumeration determined by the use of what is termed a Magic Square. With this arrangement, a well balanced traffic, devoid of the sharp peaks inherent in small groups of lines, is delivered to the local secondary lineswitch groups.

In the illustration, each primary line switch potentially has access to any one of 250 selectors, as compared to a choice of only ten selectors when the trunks from the primary lineswitches are directly connected to first selectors.

180 (b). Primary-To-Secondary Line Switch Combinations: Either plunger type or rotary type line switches may be employed as secondary line switches. Because of their greater trunk capacity, however, rotary type secondary line switches are more generally used, permitting the formation of a larger group of first selectors; thus reducing the chances of traffic congestion in any one secondary group.

The more general primary-to-secondary line switch combinations are: (1) plunger-type primary line switches to plunger-type secondary line switches; (2) plunger-type primary line switches to 25-point non-homing type, secondary line switches; (3) 11-point, non-homing type, primary line switches to 25-point non-homing type, secondary line switches; and (4) 11-point, homing type, primary line switches to 16-point non-homing type secondary line switches using a graded multiple arrangement.

For further discussion of secondary line switches see AT (Clapham) 9-20, AT (Clapham) 3-21, AT (Quayle) 5-21 and A.E.Co. Bul. 809 and Bul. 811 page 6.

Outgoing Secondary Line Switches: Secondary switches are also used in the larger multi-office systems, at the outgoing end of interoffice trunks; function, in this case, is to combine the traffic cted to a distant office (originating from the vari- groups of subscribers' lines) in such a manner all the subscribers' lines in the originating of- have access to all the interoffice trunks in each ce group. These "outgoing" secondary line ches are interposed between the local selector s and the impulse repeaters. Through their use, erial economies may be effected in the number of office trunks, associated impulse repeaters, and ming selectors required to carry the traffic load.

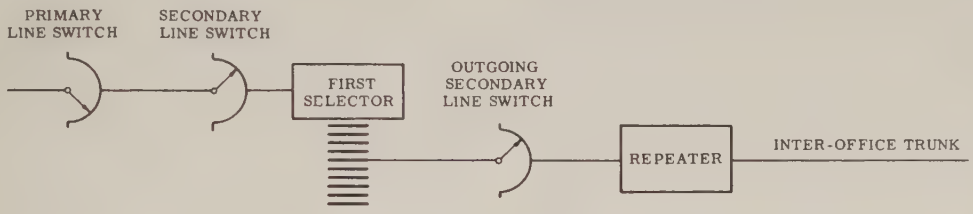



Fig. 2 - Secondary Line Switch Outgoing From Selector Level.

oing secondary line switches will be used, in ral, whenever the saving in the cost of repeaters trunks is greater than the cost of the outgoing ndary line switches, after balancing maintenance lems, etc. Either the plunger or rotary type of oing secondaries is used, depending largely on the unt of traffic.

182 Line Adapters: Line adapters (sometimes designated, (1) Grounded Line Adapters, (2) Long Line Adapters, or (3) Rural Line Repeaters) are essentially impulse correcting repeaters associated with individual lines.

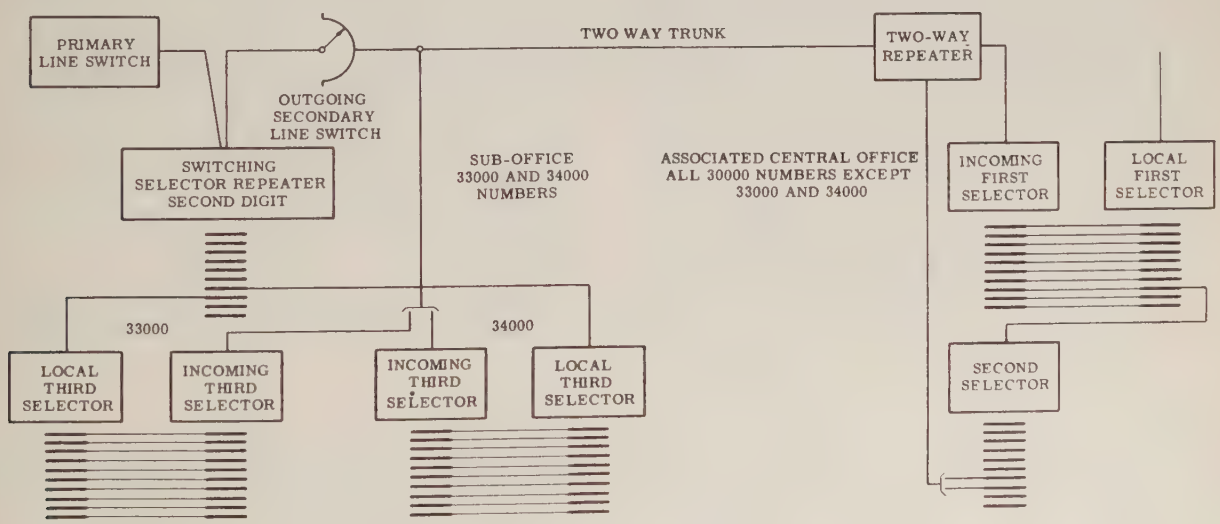



Fig. 3 - Secondary Line Switch Outgoing From Switching Selector Repeater.

(a). When Used With Selectors: Selectors ordily permit access to only ten trunks on each ; therefore, the individual inter-office trunks reached from a limited number of selectors. ce, in case of unusual fluctuations of the traffsome trunks may be idle while a heavy demand ts in some other section of the switching equipt.

rder to make all trunks accessible to a much er number of selectors, secondary line switches

The circuit description of a specific one of these devices reads as follows: "This Long Line Adapter circuit operates as an impulse repeating circuit when a call is made from the line to the dial office. When a call is made from the dial office to the line, this circuit repeats the code signal received from the link circuit. When the call is answered, this circuit trips the ring cut-off relay in the link circuit and supplies transmission battery to the called party."

183 Call Recorder: The Telephone Call Recorder permits any subscriber calling an absent party to record his own number at the called station. He merely dials the number (after first ascertaining that the called party is absent), and it is recorded on a paper tape. When the absent party returns to his office, he may immediately dial the recorded numbers, and thus establish the desired connections. The operation is simple and easily understood -- an important point in any service which is subscriber controlled -- yet it meets every requirement of this service.

The Telephone Call Recorder consists of a specially arranged pen-register and a switching key to cut the unit into and out of service. In use, it is merely inserted in the telephone line at the substation, terminals being provided for connection to the line, and to the telephone.

When the subscriber leaves his telephone he throws the key, connecting the recorder to the line. Ringing current impressed on the line by an incoming call energizes the magnet of the pen-register, and starts its spring-driven mechanism and paper feed. The mechanism immediately closes a direct-current path through the calling connector. Over this path, the ring-cut-off relay of the connector operates, and the back-bridge relay closes the current-supply circuit to the recorder.

The operation of the pen-register also produces a distinctive tone, which is impressed on the line. Upon hearing this tone, the calling subscriber knows that the called party is absent but has a call-recorder which is ready to record his telephone number. He then proceeds to dial his own number!

As the dialed impulses are received, the pen-register magnets operate in unison with them, and record the number of the calling telephone as a series of short dashes on the tape. If the call number includes letters, these are recorded as figures, but as the number may be called again by these same figures there is no confusion. After the last digit is completed, the register feeds out about three inches of tape, which serves to separate the recorded number from that which follows.

183 (a) Associated Exchange Equipment: For the operation of the call-recorder, the connector switch must be arranged to interrupt the battery feed through the back-bridge relay when the calling party dials his own telephone number. For this purpose, the busy relay is arranged as an auxiliary pulsing relay.

183 (b) For further discussion see A.E.Co. Bul. 1528.

184 Line I.D.F. Facilities: Line intermediate distributing frame (L.I.D.F.) facilities may or may not be provided in Strowger automatic telephone exchanges, their use is dependent upon local conditions and the operating telephone company's preference in the matter.

In addition to engineering considerations such as floo space, outside cable plant, expected growth of the ex change, types of services, etc., there is also th question of cost; and, therefore, the type of L.I.D.F best adapted to meet the operating telephone company requirements for each individual case can only b determined after all information is at hand.

184 (a) Cabling Plan Without L.I.D.F. Facilities When no L.I.D.F. facilities are provided in Strowge automatic telephone exchanges, the subscribers' num bers (connector bank terminals) are connected direct to the associated line equipment. The general cablin arrangement of this method is shown in Fig. 1.

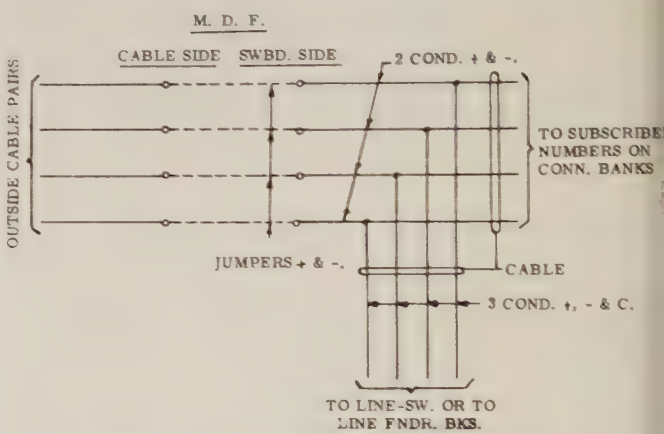



Fig. 1 - Cabling Plan Without L. I. D. F. Facilities.

As indicated in the diagram, the connector terminal and the line equipment are connected together at som terminal point associated with either group of equip ment, and one set of cables is run from this equip ment terminal point to one side of the main distributin frame. The outside cable pairs are terminated on th opposite side of the main distributing frame, and ar cross-connected to the cables leading to the equip ment.

The main distributing frame may be either of th "A" (protectors on the switchboard side) or "B" (protectors on the outside cable pairs) type, as re quired.

184 (b) L.I.D.F. Facilities: The L.I.D.F. is usuall interposed between the main distributing frame, th line equipment and the connector bank terminals This arrangement permits cross-connecting betwee the outside cable pairs, the line equipment and th connector terminals. The flexibility of cross-con necting thus acquired has advantages which are mani fold and far reaching, many of them being of intangibl value.

The principal tangible advantages may be summarize as follows: (a) Increase in Efficiency of Outsid Plant: (b) Re-distribution of Originating Traffic (c) Reduction in Amount of Line Equipment Required and (d) Provisions for Changes in Classes of Service

Increase in Efficiency of Outside Plant: When ty line service is given and no L.I.D.F. facilities provided, it is generally true that a percentage of party lines are not fully loaded. Many two-party es have only one telephone connected to the line, four-party lines often have only two or three phones.

scribers may have moved, changed their class of vice, or cancelled their contracts, and the vacated bers are not re-assigned until the next directory ssued. Such conditions may tie up enough outside de plant to cause a shortage of cable pairs and phone numbers.

n the party lines are on a terminal-per-station k-per-station) basis, the L.I.D.F. makes it possible eadily free some of the cable pairs from party ss on which only one, two or three telephones are peration. This is accomplished by re-distributing e telephones over partially loaded party lines, as L.I.D.F. eliminates the necessity of changing the phone numbers and placing the vacated numbers ntercepting service.

similar manner, the L.I.D.F. permits the tele- ne number to be retained when a subscriber moves nother neighborhood in the same office area.

re-distribution of telephones on party lines to ct economy of cable pairs and telephone numbers enerally known as "Party Line Fill."

Re-distribution of Originating Traffic: Even gh great precautions are taken in assigning lines he various line equipment sub-groups, it may pen that some of these sub-groups will become -loaded whereas other sub-groups will be under- ed.

n an L.I.D F. is employed, lines can be discon- ed from the sub-groups that are overloaded and be connected to sub-groups that are underloaded. is manner, an equal distribution of the originating fic can be maintained without the necessity of ging subscribers' numbers.

Reductions in Amount of Line Equipment Required: usually desirable to provide from two to five per- spare line equipment for each class of service he initial installation, and ten percent more con- or terminals than the number of working lines. spare line equipment is to facilitate balancing traffic among the various line equipment sub- ps, and the extra connector terminals are to care directory changes, etc.

n no L.I.D.F. is provided and the line equipments cabled directly to the connector terminals, the ber of spare line equipments and connector termi- to be furnished must necessarily be the same. e, there will invariably be an unnecessary surplus pare line equipment.

When an L.I.D.F. is used, the number of spare line equipments and connector terminals can be furnished independent of each other, i.e., it is possible to provide from two to five percent spare line equipment and ten percent spare connector terminals. It, therefore, can readily be seen that the L.I.D.F. will reduce the amount of spare line equipment in some cases as much as eight percent of the total number of lines installed. This saving is also reflected in the exchange selector switches.

The L.I.D.F. also permits a more efficient use of the line equipment on "take-outs" because the line equipment is immediately freed for re-use, whereas the affected connector terminals are placed on intercepting service until the next directory issue.

(D) Provisions for Changes in Classes of Service: Any pronounced advance in rates or a universal business depression is usually accompanied by numerous changes in the classes of service desired by the subscribers ---- individual-line subscribers will often request two-party or four-party service, while two-party line subscribers will request four-party service, etc.

Changes of this nature taking place simultaneously, have a serious effect on telephone service because such conversions cannot be readily made without changing subscribers' numbers when an L.I.D.F. is not employed.

With an L.I.D.F., in most instances it is not necessary to change subscribers' numbers, the only change required being the re-running of jumpers. The L.I.D.F. also permits more effective loading of party lines, thus avoiding, in many cases, the necessity of additional equipment or the conversion of individual-line equipment for party-line service.

184 (c) L.I.D.F. Plans: Line I.D.F. equipment may be divided into two general classifications, (1) such plans as provide "full" line distributing facilities, and (2) plans of a more or less "modified" type.

There are a number of plans available within each classification, for providing line cross-connecting facilities. The L.I.D.F. may consist of a complete self-contained framework, independent of other equipment; or it may be combined with the main distributing frame. The cost of L.I.D.F. equipment varies approximately in direct proportion to the amount and character of the facilities provided.

Each plan has its own particular advantages and cost position. In certain instances, a modified type may provide all desired facilities at a relatively lower cost than a full L.I.D.F. type. In other cases, a certain type of full L.I.D.F. may best serve the operating telephone company's requirements. The particular type best adapted for a given installation can only be determined from a study of all information relating to the case.

Space permits of only one illustration, for further discussion see A.E.Co. Bul. 339.

184 (d) Typical Full L.I.D.F. Plan: This plan provides full L.I.D.F. facilities on a self-contained frame separate from the main distributing frame. The subscribers' numbers (connector terminals) are multipled to the main distributing frame, thereby increasing the cost somewhat over some other plans. The prime advantage of this plan is that originating traffic redistribution may be accomplished by changing jumpers on only the L.I.D.F. No jumper changes are required on the main distributing frame for this purpose.

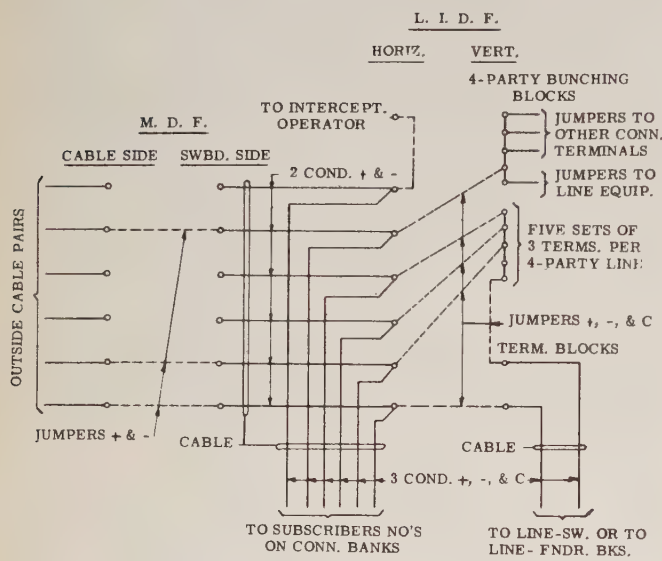



Fig. 1 - Typical Full L. I. D. F. Plan.

Referring to Fig. 1, the top line circuit is shown jumpered at the L.I.D.F. for intercepting service. The bottom line circuit represents an individual-service line; and the intermediate line circuits, two four-party lines.

On the upper four-party line circuit four connector terminals are shown jumpered to the associated bunching block on the vertical side of the L.I.D.F., and on the lower four-party line circuit three connector terminals are shown jumpered to the associated bunching block. The vacant terminal on the lower bunching block can be jumpered to any desired connector terminal to load up the lower four-party line.

The main distributing frame may be of either the "A" (protectors on switchboard side), or "B" (protectors on cable side) type, when associated with this plan.

185 Trunk Termination: In any telephone exchange network, trunks leading to unattended dial offices may be terminated in either one of two ways: (1) They may be treated the same as local subscribers' lines and terminated on regular subscriber line equipments, or (2) they may be terminated on numerical type switching equipment; that is, on incoming selectors, connectors or their equivalent.

In the following diagrams, standard Strowger line finders and selectors are shown because they are comparatively easy to comprehend. It should be realized, however, that the principles of telephone switching involved in this discussion are identical regardless of whether the switching medium is Strowger, all-relay or some other type. Also, in the case of a small exchange, connectors would be used instead of selectors. In the following discussion, where the term "incoming switch" is used, it should be taken to mean "incoming selector" or "incoming connector." These may be Strowger, all-relay, or any other type.

185 (a) Termination on Subscribers Line Equipments: The method of terminating trunks on line equipments as illustrated in Fig. 2, offers greater initial economy, since no individual or special trunk equipment is required to handle incoming traffic. There are many small CAX's with only one or two connecting trunks where the grade of service has proved satisfactory when this method of termination is used.

However, with this arrangement the subscriber or operator making an incoming trunk call will be required to wait for the dial tone and may be subject to an "all links busy" condition in the same manner as a local subscriber. This is because all toll calls are subject to the same grade of service and traffic conditions as the local calls.

There may be times when a local traffic surge keeps all links busy, causing delays for the distant operator or subscriber in setting up trunk calls. Therefore, the number of links provided must be sufficient to handle the traffic offered by both the local subscribers and the trunk lines. This requirement, under certain conditions, may prove to be uneconomical. Also, when conversation timing is used on the local calls and the trunk calls are not free service but toll calls, a special circuit arrangement is required to provide for exemption from timing.

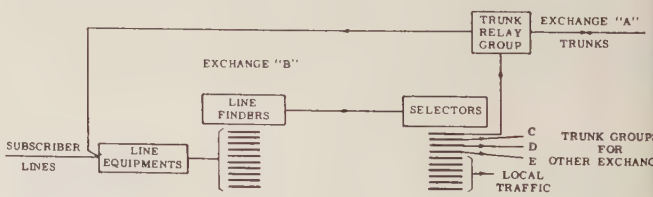


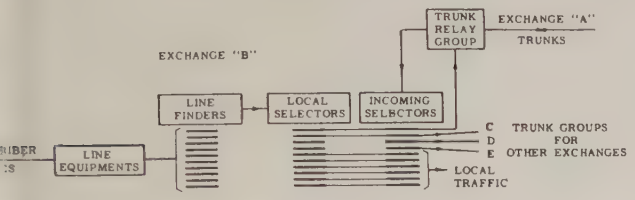

Fig. 2 - Inter-Exchange Trunks Terminating On Line Equipments.

Some types of dial equipment are so arranged that in cases where incoming trunks are terminated on subscribers line equipments for the initial installation and traffic increases to the point where this arrangement is not satisfactory, incoming switches then may be added to improve the service.

185 (b) Incoming Switch Termination Method: The outstanding feature of the method of terminating trunks on incoming switches, as shown in Fig. 3, is that this arrangement provides for incoming calls to completely by-pass the local links. Each toll or trunk circuit is terminated directly on its own incoming switch, which

complete and immediate access to both local and ough traffic paths. Thus, with a switch always ilable for handling the incoming traffic over each vidual trunk, no incoming call can be delayed or cked from completion as a result of an all links y condition in the exchange.

Discriminating Service: The need for proper tching equipment is apparent when access to cer- services is denied to the incoming trunks.




ig. 3 - Inter-Exchange Trunks Terminating On Incoming Selectors.

an example, suppose that trunk groups D and E g. 3) are to be accessible to the operator in ex- nge "A," but exchange "B" subscribers must be rred from these trunk groups (trunk group C to be ilable both to exchange "A" operators and to ex- ange "B" subscribers). This discrimination is complished merely by disconnecting the bank multi- between the local switches and the incoming switch cuit. Incoming switches also may be arranged so t operators at certain exchanges readily may be evented from connecting to specified trunks or trunk ups as required to meet desired toll operating and ording practices.

exchanges where conversation timing is in use on al calls and the trunks terminate on incoming itches, all trunk calls will then by-pass the conver- ion timing equipment.

e of incoming switches is a particularly flexible ans for providing modern and efficient methods of l supervision and transmission, since any desired erating feature can be included in the incoming trunk cuits. The "flash busy" and "camp on busy trunks" e typical examples of features which lead to efficient age of toll operators' time, as well as toll plant. The end in automatic toll switching is toward flashing gnals and the elimination of audible tones, in which se it will be necessary that the exchange equipment arranged for incoming switch termination of toll unks in order to by-pass the local tones. It is not nsidered good practice, even at the present time, make toll trunk calls dependent upon local service uipment.

) Universal Numbering: Universal numbering ser- e between groups of exchanges or between exchanges the same group, may be provided more easily when coming switches are used. Likewise, in small ex- anges where tandem trunking is provided, the in- ming trunk switch can be arranged to absorb digits drop back on certain levels to provide the most tisfactory numbering scheme.

185 (c) Comparative Advantages: There are no technical reasons why incoming switches cannot be employed on any dial switchboard -- whether Strowger, all-relay, or other type. In Strowger practice, incoming switches are the rule rather than the exception, because the service advantages far outweigh the small extra expense involved. In relay systems, incoming switches are no less desirable, but it generally has not been the practice to supply them, presumably on the grounds of cost and the complex wiring and mounting problems which are involved.

A study of costs and service advantages should be made if there is any doubt as to the best plan to follow. Termination of trunks on subscriber line equipments may be satisfactory in certain cases of small exchanges that are not tandem points for calls to other exchanges, but it is clear that in the majority of cases the use of incoming switches provides many advantages, and in tandem exchanges they are a practical necessity.

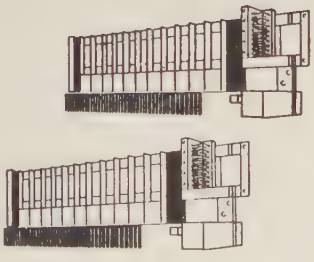
Certain of these advantages are assuming major importance due to the growth of automatic toll switching, where speed and efficiency are the rule, and where even slight delays are subject to criticism.

186 Rack Mounted Equipment: When a basic design is fundamentally sound it will carry on throughout the years with little or no change. In this section we will compare Strowger rack mountings of the year 1945 with those in use in 1905.

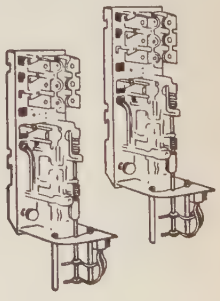
A recent advertisement reads in part, "Strowger equipment is designed for growth - engineered specifically for easy, trouble-free axpansion. On its standardized frames are mounted switch shelves of



STANDARD FRAMES... are rigid, welded-and-bolted steel structures of standardized design, upon which the shelves are easily mounted.



STANDARD SHELVES . . . provide mounting facilities and switch jacks, with all wiring completed to a terminal block at the end of each shelf.



STANDARD SWITCHES . . . each comprising a complete switch mechanism with associated relays —wired, and with wiring terminated on a "jack" on the base.

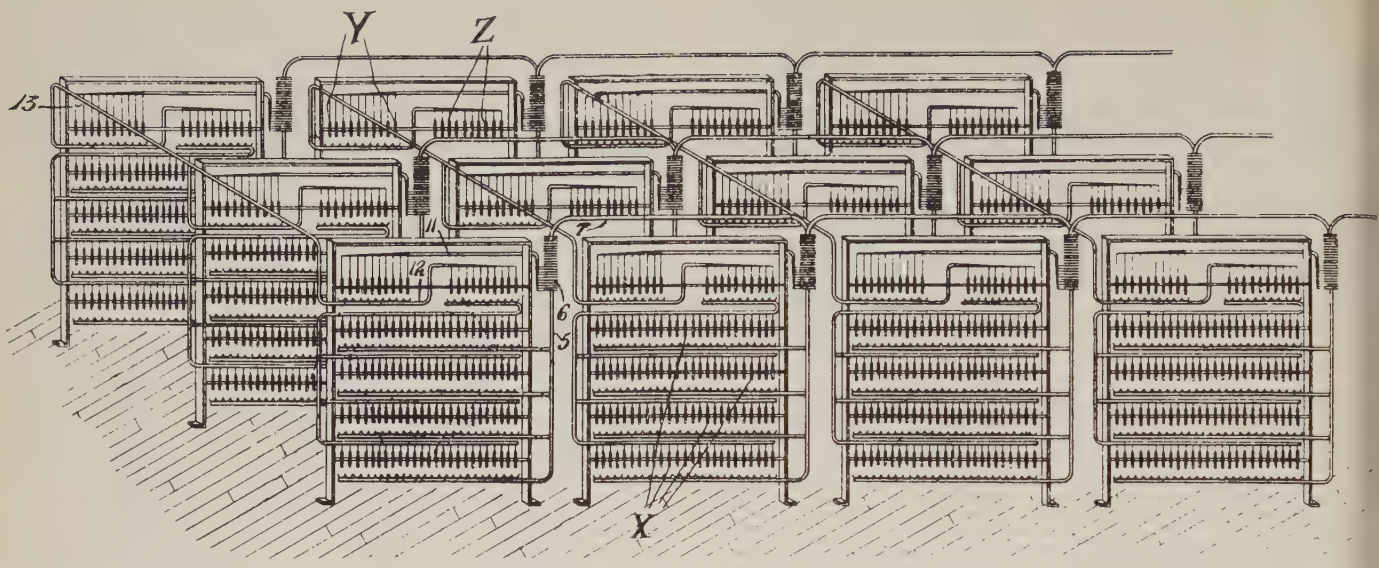



Fig. 1 - Keith Patent No. 831,876 (Application Filed March 9, 1905).

various standard types. On these shelves, in turn, individual switches are quickly "jacked in" as needed. For further growth, you add new shelves or new frames with equipment as required. No matter how large the addition may be, existing equipment and wiring are not disturbed".

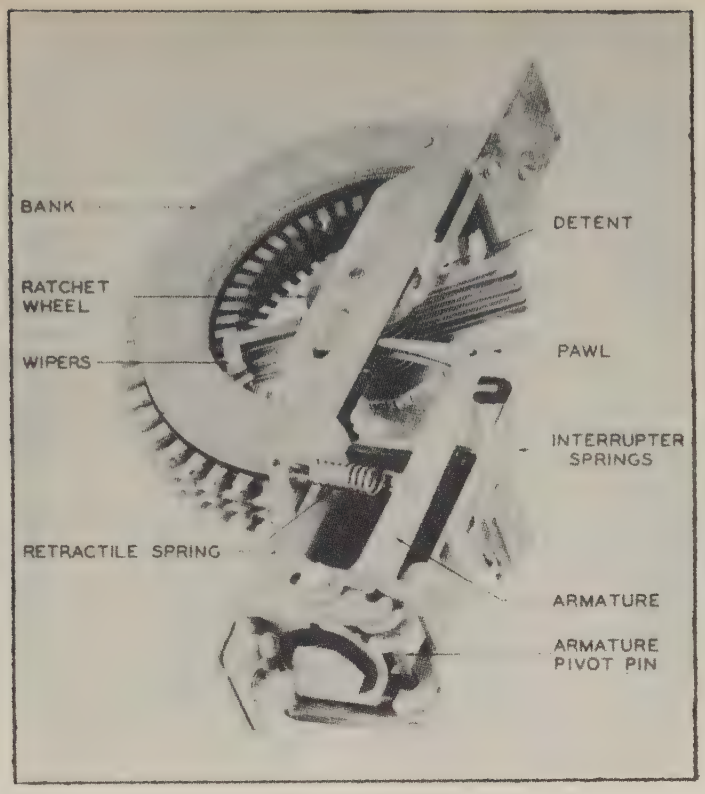
Refer now to Sec. 186(a) which is primarialy a discussion of trunking, but which also illustrates rack mounted equipment as installed in 1905.

186(a) Details of Trunking: Figure 1 is a reproduction of Fig. 2 in U. S. Patent 831,876 (Keith, application filed March 9, 1905), and is a view of a part of a 10,000-line Strowger switchboard. Each frame (one hundred line board) supports five shelves, each shelf having 25 switch mounting positions. The lower four shelves on each frame carry one hundred first selectors, the upper shelf mounts the associated second selectors and connectors.

Figure 1 represents one corner of a switch room. The three upright frames at the left are part of the first thousand, the three in the row to the right the second thousand, and so on. Each subscriber's line terminates in an "individual" first selector X (this was before the days of the line switch). The second selectors are shown at Y and the connectors at Z. There are ten of each on a board.

The wires from the banks of the first selectors are gathered into the "first selector bank cable" 5, and carried to a terminal rack 6. A "first selector multiple cable 7, connects these various banks together from board to board, running between like hundreds in the different thousands. All these cables carry 100 trunks, corresponding to the capacity of a selector bank. A small cable 11, called the "first selector cable", taps off ten trunks at each board and runs them to the ten second selectors on each board. The distribution of trunks from the banks of the second selectors follows the same plan, which is like that described for the selectors of the 1000-line system. The second selector bank cables run to a terminal board (not shown) and are connected together from board to board in the same thousand by the second selector multiple cable 13. Small taps of ten trunks each are taken off through the second selector trunk cables 12, which terminate in the connector switches Z.

187 Dial-Back Equipment: Dial-back equipment enables a toll operator to complete connection between subscribers in two different exchanges, by dialing back on the same trunk over which she received the call. For further discussion see, "Remote Control Dialing" STJ 12-38.



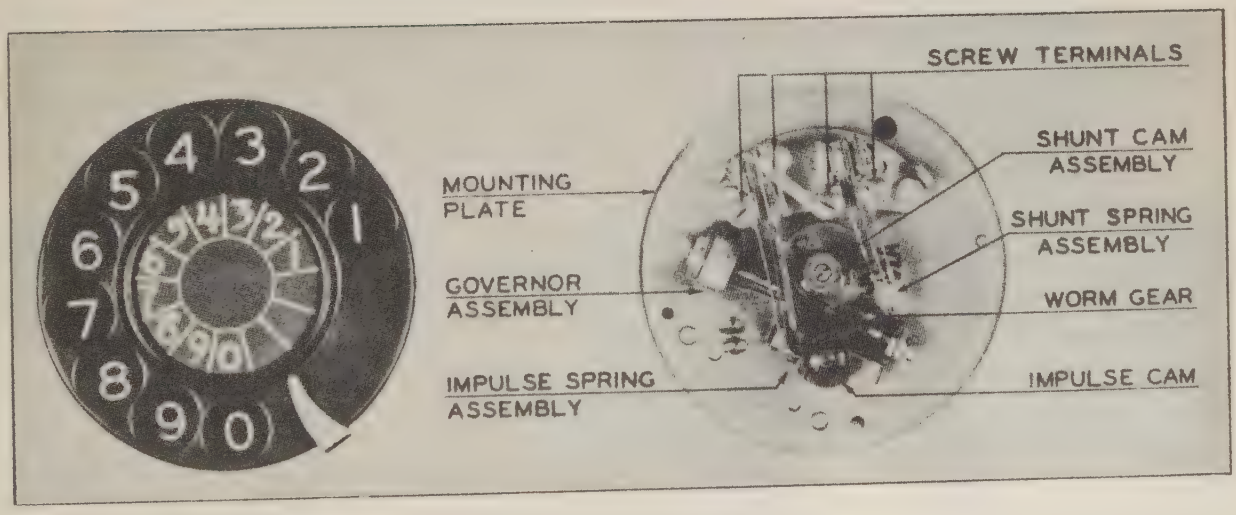
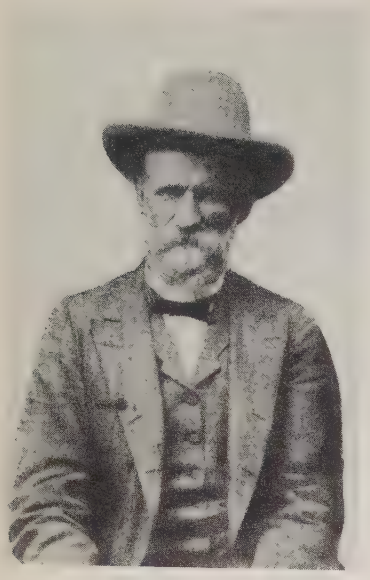




PLATE E - Rotary Switch Mechanism. This switch may be used as a Line Switch, as a Line-Finder, as a Connector or as a Remote Control Unit.

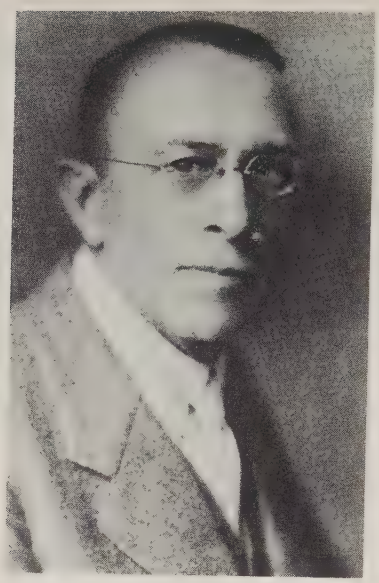
- Dial. Note Luminous numerals appearing on the dial card.

(1839 - 1902)



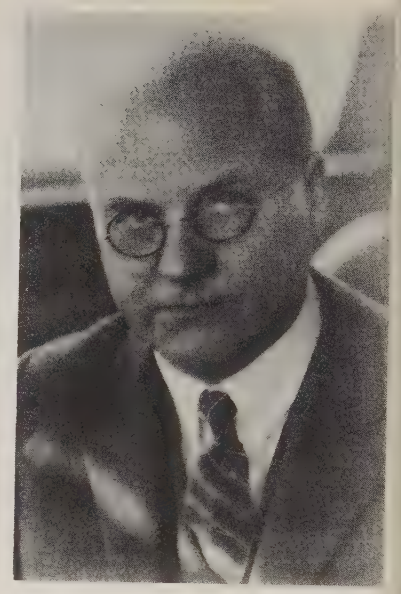
A. B. Strowger

(1863 - 1926)



A. E. Keith

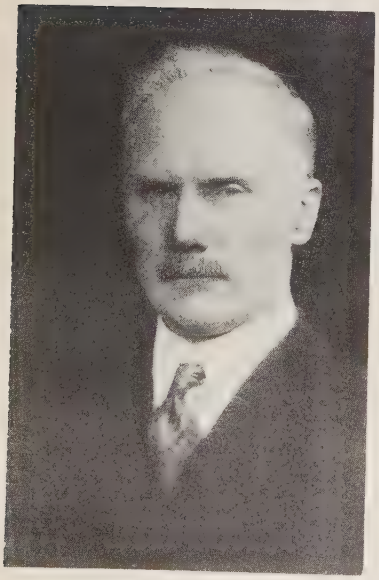
(1866 - 1943)



John Erickson

But for MEN such as these, there would have been no Strowger Automatic.

(1870 - )



Charles J. Erickson

(1875 - 1921)



W. Lee Campbell

(1865 - 1935)



T. G. Martin

# PART B - HISTORICAL

historical comment presented in this part is ted in sections which correspond with simi- y numbered sections in Part A. Its understand- presupposes some working knowledge of Strowger omatic, but even so, some terms may appear in nat are understandable only to those who have own up in the business." This is inevitable, and reader should not be too much concerned if such ms are unfamiliar.

. Subscriber Station Equipment: The "Magna ta" date line in Strowger automatic develop- nt was the year 1907. In that year the invention he "2-wire" system freed the Strowger Auto- ic from the complexities of a dual impulse cir- over the line wires, eliminated the ground at the scriber station and permitted greatly simplified ion equipment. The older system has since been ded the "3-wire" system, which is a misnomer, ce the system actually had only two line wires. A d comparison of the two systems, by the man who eived the basic 2-wire patent, will be found in AT llinger) 3-19.

ferring to Sec. 400, note that the early 2-wire scriber station had a very simple circuit. As the rs went by it was largely a matter of "keeping up h the Jones." Since any telephone in the world y be connected to any other telephone it was as- med, a fortiori, that every telephone must be of a lity which would permit its being connected to an- er telephone on the other side of the world. As so en happens, the masses were penalized for the ad- ntage of the few.

otographs of Strowger Automatic telephones rang- from 1892 to 1922 will be found in AT 9-22. The st description of the "Monophone" will be found AT 9-25, of the "Colored Monophone" in AT 5-29, d of the "Self Contained Desk Monophone" in AER 29.

1. The Dial: The present dial is of the "return- le" type (as were all 3-wire dials), and within mits it is possible for a subscriber to speed up or tard the action of the dial during the return move- ent, (note instructions on the dial shown in Fig. 1) .

1 (a). This possible "forcing" of the dial was one the bugaboos loudly proclained about the time 2- re was getting into production. An early 2-wire al (Fig. 2) was therefore made "non-returnable" locking. The finger plate had eleven holes and uld be rotated clockwise from the desired digit to e finger stop. The finder plate locked when the op was reached, and was not again free to be moved rward until the impulses representing that digit had en sent.

201 (b). It is apparent that the minimum time between successive digits will depend both on the digit dialed and the speed with which the subscriber turns the dial during its forward motion. In the case of the higher digits, 0, 9, 8 etc., there will be ample time between digits, no matter how fast the subscriber may dial.

Referring again to Fig. 1, note that the angular displacement of the "1" hole, with respect to the finger stop, is the same as the angular displacement from






Fig. 1. - Returnable Dial Displaying Caution Note.
Fig. 2. - "Non-Returnable" or Locking Dial.

hole to hole. Using a dial of this general type, it might be possible for a subscriber to dial the digits 1111 faster than they could be accepted by the Strowger switches.

201 (c) The dial shown in Fig. 3 is of the "Delayed Impulse" type and the angular displacement between the "1" hole and the finger stop is approximately twice the angular displacement from hole to hole. As



Fig. 3. - Delayed Impulse Dial.

explained in AT (Obergfell) 3-26, this "introduces a time element between the successive digits of a telephone number which is being dialed in order to give the switches ample trunk hunting time," see Sec. 110.

The result is accomplished by a second cam attached to the main dial shaft which cam moves the two pulse springs out of engagement with the pulse cam during the last one-half revolution of the pulse cam.

201 (d). The dial brought out in 1924 was designed by Obergfell and manufactured by Doyle, and has since been called the "Thousand Year Dial," see AT (Baer) 5-27. Various attempts have since been made to produce a "simplified" or "low cost" dial, but the failure of such attempts is evidence that the old 24, besides being an excellent performer, is an economic design as well.

201 (e). In view of the coffee grinders which were then so prevalent, it is a wonder that anyone should have attempted to further quiet an already quiet dial.

However, see AER (Obergfell) 9-37 in which the "Quited Dial" is described as having "clickless pawl action."

201 (f) In the language of biological evolution, a mutation is a sudden departure wherein the off spring differs from its parents in some well-marked characteristic. One of the interesting mutations which occured during the evolution of the dial was the so called "Sanitary Dial" shown in Fig. 1. This, like so




Fig. 1 - Sanitary Dial.

many biological mutations seems likely to fail to meet the test of survival. As written up in AER 9-37, the "cutaway finger plate facilitates cleaning." While on the subject of evolution we direct attention to the excellent article in AT (Obergfell) 3-27 which discusses and illustrates all dials developed from 1895 to 1924.

201 (g). The industry having been quite successful in persuading the subscriber to do his own work, it is a bit paradoxical that through the years pressure was continually exerted on the designers to do something to lighten that burden. A long line of "executive calling devices" were worked upon, all of which died a-borning, until the Autodial" came along. This was described in AER (Clapham) 9-37, as "a device which automatically does the dialing for the user of the automatic telephone. The user selects the names of those persons that he calls most frequently and lists them on the Autodial directory card. The user then simply sets the pointer opposite the name of the person he is calling, removes the handset, presses the lever, and Autodial does the rest."

201 (h) For article on dial maintenance see AT (Schwartz) 6-19.

202. Grouping of Sibscribers: Manual switchboard development was away from trunking between the various sections or positions of a board (because, according to Smith & Campbell, "of the inefficiency of human beings as switches"), and toward the multiple idea of operating, wherein each operator is able to complete the connection with any line in the same office.

The Strowger Automatic system is essentially a trunking system where the calling line is extended a step at a time until it finally reaches and connects with the called line.

A ten thousand line manual multiple is a costly thing as compared with an operator's position, but the combination is efficient because many (simultaneous) connections can be established via a single operator's position. In any system of machine switching careful thought must be given to the cost of the switching mechanism as against that of the bank to which it alone has access. This point will be discussed in later sections. Here we need merely say that Keith, Erickson, and Erickson were pretty well right when they equipped the Strowger mechanism with a 100-point bank.

203. Strowger Mechanism: The Strowger mechanism, like the Dutchman's wife, "may not be much for looks, but is hell for work", as proved by the following chain of events.

In 1904 Strowger equipment was sold to the Citizens Telephone Company of Grand Rapids, Michigan under a most remarkable guarantee which, among other things, "bonded the maker to replace any worn or defective equipment for seven years without charge." The total cost of the guarantee to the manufacturer, for the entire seven years, was about 15 cents per connected telephone.

After fifteen years of operation, Tarte (in AT 1-19) reported on the 16,000 Grand Rapids stations as follows: "Of course certain small wearing parts such as wipers, pawls and the like, have been replaced on many of the switches. Springs have burned out and have been renewed. But the banks, and bank contacts, relay magnets and frames, all the principal parts of the switches, are those with which we started fifteen years ago."

After twenty one years operation (see AT 1-26), more than eight thousand of the Grand Rapids Strowger switches, many of which had been in continous service since 1904, were rebuilt completely to conform with modern (3-wire) circuits. The switches, were stripped to the frame, reassembled, and afterward wired with new circuits of the very latest type. The writer was in charge of the actual rebuilding, and knows that the switches were then good for many more years of service.

At the time this section was written (1944), Wagner was successfully rebuilding Strowger switches of the 1915 vintage (2-wire) into very acceptable P.A.X. and C.A.X. jobs.

The Strowger mechanism is very versatile, and has suffered numerous indignities; at one time it was laid down on its back and made to operate an extended shaft carrying six times the usual number of wipers; when it first entered Navy service a coiled spring was attached to the lower end of the shaft to insure that it would restore to normal in a rough sea.

The trend, since 3-wire days, has been in the direction of fewer mechanical gadgets and toward more complicated circuits but, even so, a modern Strowger mechanism when fully dressed might have all of the following decorations; "vertical off-normal springs" operated as the shaft takes the first vertical step; "normal post springs" operated when the shaft has

665247

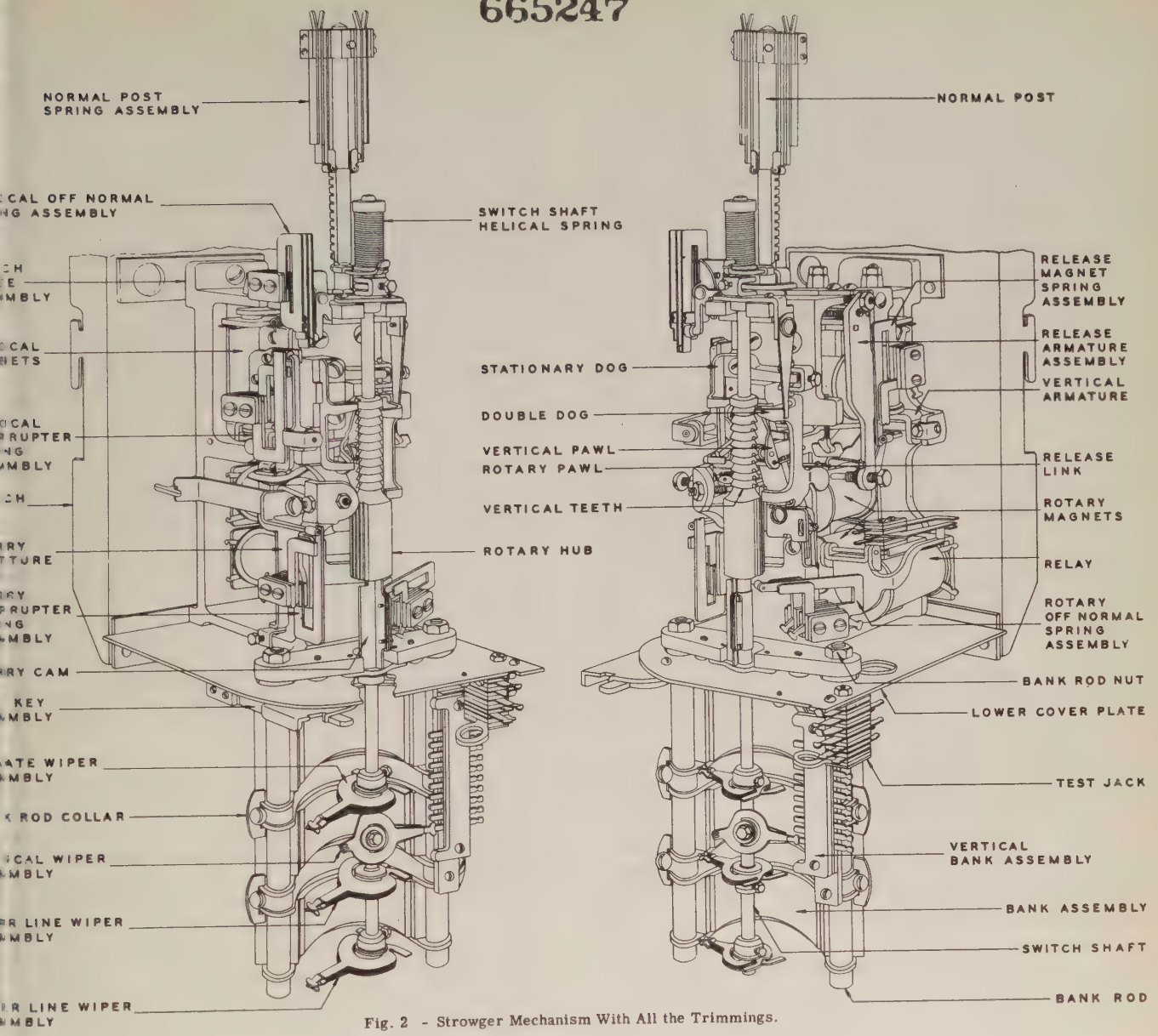



Fig. 2 - Strowger Mechanism With All the Trimmings.

n one or more vertical steps; "rotary off-nor- springs" operated as the shaft takes the first ary step, on one or more levels; "rotary cam ngs" operated when the shaft takes the eleventh , on one or more levels; "vertical interrupter ngs" operated at each vertical step; "rotary in- upter springs" operated at each rotary step: and ease magnet springs" operated when the release net is energized. (See Fig. 2).

(a) A discussion of the Strowger mechanism d not be complete without reference to the B.P.O. tish Post Office) or English version. According .E.Co. Bulletin 356, among the several improve- ts sought were: (1) reduction in overall dimen- s, and (2) higher hunting speed. Actually the ng in cubic space was about 40%, and the hunting d was approximately doubled.

standard mechanism, as we know, has an "up, nd, and return" movement; that is, it releases by retracing its original path. The B.P.O. mechanism operates through a so-called rectangular path; that is it releases by continuing the rotary action until the wipers are off the level, whereupon the shaft drops vertically downwards, then turns back to its original position under spring control.

204 The Strowger Bank: To keep the nomenclature straight, for this text at least, remember that a Strowger mechanism has access to a 100-point bank (or banks), the word "point" meaning "objective."

One type of bank consists of 100 single contacts, set in 10 horizontal rows of ten contacts each, and is usually called a "private" or control bank.

In this text such a bank will be designated a 100-contact bank. Another type of bank consists of 100 pairs of contacts (upper and lower), set in ten horizontal rows of ten pairs each, and is called a line-bank. Note however that the latter bank could function

equally well as two private or control banks. In this text such a bank will be designated a 200-contact bank.

Those who would drag the fair name of Strowger in the dust are prone to point with scorn to its "small capacity banks." Keith, Erickson and Erickson, when they designed the system, could scarcely have foretold that years later both Molina and Erlang were to write very learnedly of the comparitive efficiency of small and large trunk groups. (See "Methods of Calculating Switch Quantities," A.E.Co. Bul. 2011).

This text cannot go into that subject, which is a matter for specialists, since the writer is merely a rolling stone that has gathered very little moss. A few observations, however, may set the reader to thinking.

Let us assume a certain "average traffic" per line (incoming) and a certain "grade of service," such that, according to the tables, ten switches (final selectors, connectors, or any other name you care to give them) will satisfactorily serve a group of 100 lines. If the group is increased to 200 lines, and each switch is capable of connecting with any line in the group, only 16 switches will be required.

So it goes, a 300 line group may be served by 22 switches; 400 lines by 28: 500 lines by 33; 600 lines by 38; 700 lines by 43; 800 lines by 48; 900 lines by 53 and finally 1000 lines may be served by only 58 switches capable of connecting with any line in the group.

Thus it will be seen that large groups increase switch efficiency, but decrease bank efficiency. A thousand line bank which can be used for only one connection at a time is certainly far from efficient.

204 (a) Mahoney's switch, mentioned in a preceding section, was a Strowger mechanism laid down in its back and made to operate an extended shaft carrying eighteen wipers. The bank assembly consisted of nine 200-contact banks, through which a three conductor circuit could be extended to any of 600 objectives. It was in effect, a 600-line switch. This switch operated satisfactorily, but never went into production, largely because of its costly bank.

204 (b) A Strowger mechanism, associated with three 200-contact banks, has long been used as a "200-Line Connector." see Sec. 132; as a "200-Line Finder", see Sec. 209; and as a "10/20 Selector", see Sec. 210 (i). In each case, a 3-conductor circuit may be extended by the switch in question to any of 200 objectives.

It would seem that K.E. & E. hit upon a very happy compromise between switch cost and bank cost.

204 (c) Microphonic coise is somewhat like a haunted house. Some people can hear the spirits but most people cannot. The writer personally never met up with a microphonic noise, either real or imaginary. The millions of "base metal" contacts in Strowger offices have caused a lot of comment and perhaps some microphonic noise, but if the banks are maintained in accordance with the advice given in A.E.Co. Bul. 506 there will be little need for comment and no microphonic noise.

As the writer recalls the story, it was the Bell Telephone Laboratory who fathered the idea of silver plating Strowger bank contacts. This was another beautiful theory that went wrong, for the silver "migrated" across the insulators, whereupon spirits of an even more vicious variety materialized in a most disconcerting manner.

204 (d) One talking point in favor of the B.P.O. switch is that it "burnishes" all the contacts in the level to which it is raised. The standard switch, of course, does not.

205. Strowger Connector: The purpose of this section is to present the various functions of a simple standard connector in an understandable manner and without necessity for detailed circuit study. The reader will learn in a few hours study of this section many facts which normally would be acquired only after years of studying individual circuits. New connector circuits are brought out at the rate of about fifty a year, so it is hopeless to keep up via individual circuit study. These new circuits are, in general, devised merely to meet variations of the basic functions discussed in this section.

The student engineer, who has studied this section should be able to read any new connector circuit with complete understanding as he recognizes, one after another, the old familiar functions, even though they may be combined to accomplish a new over-all result. Thus circuit reading becomes easy when the student understands the basic principles underlying the result to be accomplished by any given circuit.

The subject opens with a thorough discussion of the simplest form of connector. Each of its "functions" is analized in order of occurrence, and conflicting nomenclature is reconciled. Furthermore, the historic development is outlined where of interest, and the reasons for the various circuit designs are presented.

205 (a) The connector functions described hereunder are those of what might be called a "simple, standard connector" - that is, one having none of the special features of the more complicated connectors used for selective ringing on party lines, trunk-hunting to private exchanges, and the like.

Such a simple connector might be one of those used in the 100-line system described in section 107, or it might be the final switch in the train of switches used to set up a connection in a larger system. In either case, it is used to complete connections to the terminals of called lines, and it is controlled by the two sets of impulses representing the last two (or only two) figures of the number of the called station.

(b) Seizure: In the circuit under discussion, the
d conductor is on open circuit within the connector
n the connector is at normal; as a general rule,
r connector circuits are designed for use with
ttery searching selectors" (See Sec. 210 (d).
t third conductor is then normally connected
ugh a relay or resistance to "-" battery.

n this connector is seized, ground is returned
this third conductor to hold the preceding
ches operated, and to guard itself against seiz-
Thus it is evident that this third conductor is in
ity a "holding trunk," but that specific desig-
on has never been used in this connection. The
n "holding trunk" has been used to designate the
th conductor between primary and secondary line
ches. See Sec. 180.

(c) Sequential Operation: In early Strowger
ches a sequence switch (termed a "side switch"
ng, in the case of the connector, four side switch
ers and three possible positions, see Sec. 335 (c) (A)
first used to direct the dial impulses to the vert-
magnet, then to the rotary magnet, and finally to
the switch in "ringing and talking position."

use of a sequence switch makes for simple cir-
s, but introduces certain mechanical difficulties.
wger practice long ago gave up the sequence
ch in favor of relay controlled sequential opera-

(d) Connecting the Wipers to the Called Line:
connector under discussion serves one hundred
s and its wipers have access to a 200-contact
bank and a 100-contact private bank by the usual
hod in Strowger operation. Note that the word
ontact" is to be understood as synonymous with
word "terminal." When considering the group of
s served by a connector, our literature has fre-
ntly used the word "point" as though it were
onymous with the word "line."

r connectors serving line groups of other sizes
- "The 200-Line Connector," Sec. 132; "The
Line Connector," Sec. 133; and the "Ten-Line
nector" Sec. 133.

(e) Connector Normals, Open or Closed: The
nector under discussion has three wipers, two of
ch are designated "+" and "-" on the circuit
wing, and a third which is designated "T.T."
s third wiper is termed the "private wiper," and
ater circuits is designated by the letter "C", the
er circuits commonly used the letter "P."

other variation in wiper nomenclature which oc-
ionally will be encountered is a designation "T
"), R (ring) and S (sleive)."

circuits leading from the bank contacts of the
nectors to their corresponding line equipments
e termed "connector normals". The general rule
hat the "+" and "-" line normals are "closed";
, are permanently wired to the "+" and "-" con-
ductors of the called line. The exception will be found where a multiple of the connector banks is carried to certain types of manual boards. Here the line normals are wired to appropriately positioned make springs in their associated line equipment. It follows then that the tip and ring of the manual jack will be dead until the sleeve connection has been made and the associated B.C.O. relay has operated, otherwise the insertion of the manual plug would momentarily short circuit the "+" and "-" line.

The "+" and "-" bank contacts are "non-bridging"; i.e., so narrow that the line wipers will not bridge contacts as they pass over the bank, thus assuring no interference between adjacent lines. The private bank contacts, however, are of a width such that the private wiper "bridges" adjacent bank contacts, thus permitting "automatic trunk hunting." See Sec. 210(b).

205 (f) Testing the Called Line for Busy: The line wipers of the connector under discussion are open while the switch is rotating in response to the last digit dialed, but the "RT" wiper at this time is connected thru to the busy relay. So, if the called line is in use, the busy relay will operate and give the calling party the busy tone.

The general rules are: (1) that the calling party will be locked out and given busy tone when the called line is in use; and (2) that the busy tone will continue to be received even tho the called line becomes idle.

205(g) Prevention of Further Rotation: In the event that the called line is idle, ground on the "RT" wiper of the connector under discussion passes thru the wiper-closing relay and thence to the B.C.O. relay of the called line. The B.C.O. relay operates and clears the called line of attachments. The wiper-closing relay operates and opens the circuit to the rotary magnet.

The general rule is that the wipers of a connector cannot be further advanced after the final digit of the called number has been dialed.

205 (h) Ringing the Called Line: The wiper closing relay also functions to complete a circuit from the ring cut-off relay to the "+" and "-" line wipers.

205 (i) Ringing Generator, Battery Connected or Ground Connected: In the connector under discussion, "battery connected generator" is fed to the called line thru one winding of the ring cut-off relay, the circuit to ground being completed by way of break springs on the same relay. When a "ground connected generator is used, battery only is fed to the called line thru one winding of the ring-cut-off relay, the circuit being completed by way of break springs on the same relay and thence thru the secondary of the ringing transformer to ground.

205 (j) Relative Advantages of Ground and Battery Connected Generator: Where outside plant construction is predominantly open wire, the use of ground connected generator reduces false ring cut-

offs resulting from low resistance grounds due to leakage caused by trees, broken insulators, etc. In this way it is possible to render service to lines which are below the normal standard for automatic equipment. For a discussion of Line and Trunk Standards see A.E.Co. Bul. 536.

Where outside plant construction is predominantly cable, low resistance leads between conductors occur more frequently than do low resistance leads to ground. Battery connected generator here has the advantages: (1) it is not necessary to provide current limiting devices in the connector, and (2) it protects a damaged cable from high ringing voltages.

205 (k) Instantaneous Ring-Cut-Off: In the connector under discussion, the called subscriber may answer and cut off the ring during a ringing period, as well as during the silent period. This was not possible under the older circuits.

The ring cut-off relay, which is unaffected by the passage of ringing current because of its copper sleeve and collar, is of interest because of the fact that the same coil is employed in the relay, irrespective of the frequency of the ringing current used.

In modern code-ringing connectors, instantaneous ring-cut-off is employed as a general rule, but twenty-party connectors are an exception.

205 (l) Ring Back Tone: Early circuits did not include ring back tone, but the service was demanded because subscribers wanted to know that they had successfully dialed to the ringing position. The first thought by both engineers and subscribers was that the ring back tone should not be applied when ringing into a disconnected line and the connectors were so made. It was later found that cable capacity, line leaks, length of line, number of ringers, etc., on the called party's line made such a variation in the volume of received tone that it could not definitely be known if the line was or was not disconnected. In later practice it was found desirable to return ring back tone of uniform volume, regardless of the condition of the called line and even though connection was not established therewith. The connector under discussion is an example.

Harmonic connectors, at one time, returned a ring back tone which corresponded to the frequency which was being sent. This resulted in confusion because subscribers were not sure they were receiving ring back tone, when the tone they heard was of an unfamiliar frequency. This was later corrected by employing ring-back tones of one frequency for all harmonic connectors.

It is customary to give a coded ring-back tone when code-ringing connectors are used. The code tends to advise the calling party whether he has dialed the correct code.

205 (m) Draining Condenser Charge: A code ringing 20 party connector usually has a circuit which absorbs the condenser charge on the called line, after each ringing period.

205 (n) Answering Supervision (Reverse Battery) In the connector under discussion, the answering of the called party causes a reversal of polarity on the calling line, which may be utilized to effect "answering supervision" should the call have originated in a manual board. This reversal of battery may also be used to operate a service meter (message register) or a coin collector.

205 (o) Booster Battery Metering: The connector under discussion not only reverses battery to the calling line when the called party answers, but also replaces the direct ground on the release trunk by ground thru a 45-volt booster battery which momentarily operates a marginal relay which in turn operates a service meter (message register).

205 (p) Last Party (may be either the calling or called party) Release of Connector: The connector under discussion will remain in an operated position until the last party has restored his receiver, but will permit the preceding switches to release should the calling party disconnect first. To accomplish this, ground is removed from the release trunk only long enough to allow the preceding switches to release, after which the ground is again restored to protect the connector against seizure by another selector.

Should the called party restore his receiver before the calling party disconnects, a supervisory lamp (Supy. #2) will light to indicate that fact. Should the calling party disconnect before the called party restores his receiver, a supervisory lamp (Supy. #1) will light to indicate that fact.

205 (q) First Party (Calling Party), Release of Switch Train: In this case only the calling party controls the release; and should he be the first to restore his handset the connector will release and open the circuit to the B.C.O. relay of the called line equipment. Since the called subscriber has not yet replaced his handset, his associated line equipment will function to tie up trunking switches unnecessarily by initiating a new call. It is sometimes claimed that this is preferable to tieing up a connector, as it permits checking such tie-ups as part of the regular "permanent line" routine.

205 (r) For a complete discussion of a specific simple standard connector, see A.E.Co. Bul. 807. For a discussion of all connectors used in a modern Strowger office see A.E.Co. Bul. 654.

205 (s) For article on the development of the busy feature, see AT (Clapham) 1-21; of the release feature, see AT (Martin) 1-19; and of the ringing circuit, see AT (Clapham) 6-20 and AT (Tarte) 3-21.

206 Strowger Line Finder: The writer is somewhat embarrassed, when discussing finder switches, because of the following unfortunate statement which appeared in the third edition (1920) of this text: "One

he later developments in finder switches makes of a mechanical structure identical with that of rotary line switch. The number of lines, there-, to which any finder switch has access is limited he diameter of the finder switch bank. It is this itation which will probably confine the use of find-switches to P.A.X. installations."

n the fourth edition was published in 1924, the owger finder was not yet dry behind the ears, and as thought best to ignore it entirely. Time mar-s on; and although the writer firmly believes the ustry would have been better off had there never n a finder, the time has come for a thorough ussion of the subject.

gles, writing in AT 9-28 said, "As early as 1904 owger engineers developed a number of finder tches employing a two-motion Strowger mechan-. Until recently, however, no extensive use had n made of finders of this sort. During the past ee of four years a great deal of development work been done to improve on the earlier schemes, now there are a number of telephone exchanges bloying this type of finder."

Strowger finder caught on very slowly, perhaps to the fact that Keith favored his "plunger line ch," or perhaps the advisability of the finder sys-was questioned, (1) because of the obvious fact lines in the lower levels would "steal" finders n lines in the upper levels, (2) because the sub-ber could not dial immediately upon removing receiver, and (3) because a common piece of ap-atus (the equivalent of a sequence switch) was still ired to preselect the next finder to be used.

(a) The 100-Line Finder: The Strowger switch, its ten vertical and ten rotary steps, makes an l 100-line finder. Assume a group of 100 lines, having its own individual line equipment, to-er with proper facilities for "marking" (1) the l and (2) the contact within that level; it follows that the Strowger switch can "find" any calling within the group by finding first the marked level, then the marked contact in that level; and it will in the process not more than ten vertical steps, wed by not more than ten rotary steps.

a finder is equipped with one 200-contact line and one 100-contact private bank. It therefore "find" or by "backward selection" serve one ired 3-conductor circuits.

The finder switch in question has a "vertical bank" made up of ten contacts which correspond to the ten switch levels. When a finder is started, it searches vertically until a marked contact is reached in the vertical bank, then automatically "cuts-in", and finally searches for a marked private bank contact in that level.

The one hundred lines will be served by a plurality of finders, the actual number being determined by the average calling rate for that particular group. For the immediate discussion, let us assume that the banks of all finders are "multipled straight" and that a distributor of some kind preselects the next finder to be used, as soon as the finder in use "cuts through." The traffic may be so heavy during the busy hour, that the finders are started one immediately after the other, in which case calling lines in the lower levels would steal the finders. Calling lines in the upper levels would then be delayed indefinitely, because each finder would cut-in at the lowest marked vertical contact. By the same line of reasoning, calling lines at the left of a given level would have preference over lines further in on that level.

206 (b) Preferential Hunting: This is a "half-donkeyed" scheme which "results in the establishment of a uniform and satisfactory minimum hunting time, and reduces the probability of lines in the lower levels stealing finders from lines in the upper levels to a negligible factor in the cases of simultaneous calls," according to A.E.Co. Bul. 2004, 5-31.

Preferential hunting is accomplished by dividing the finders which serve a given hundred lines, into two groups, "A" and "B". The banks within each group are "multipled straight," but there is a reversal of the multiple between group "A" and group "B", as shown in Fig. 1. Note that the number assignment in group "A" conforms to the stepping of the Strowger

| GROUP "A" | GROUP "B" |
|---|---|
| 01 02 03 04 05 06 07 08 09 00 | 11 12 13 14 15 16 17 18 19 10 |
| 91 92 93 94 95 96 97 98 99 90 | 21 22 23 24 25 26 27 28 29 20 |
| 81 82 89 80 | 31 32 39 30 |
| 71 72 79 70 | 41 42 49 40 |
| 61 62 69 60 | 51 52 59 50 |
| 51 52 59 50 | 61 62 69 60 |
| 41 42 49 40 | 71 72 79 70 |
| 31 32 39 30 | 81 82 89 80 |
| 21 22 23 24 25 26 27 28 29 20 | 91 92 93 94 95 96 97 98 99 90 |
| 11 12 13 14 15 16 17 18 19 10 | 01 02 03 04 05 06 07 08 09 00 |

Fig. 1 - Number Assignment in Switch Banks of Group "A" and Group "B" Finders.

switch (lines 11 to 10 are in the first level; lines 21 to 20 are in the second level, etc.), but that in group "B" the lines are assigned in reverse order so far as the levels are concerned. Lines 01 to 00 will be found in the first level, lines 91 to 90 in the second level, etc.

In Fig. 1 is shown the vertical bank of a typical group "A" finder, and the vertical bank of a group "B" finder. All of the vertical banks in each group are "multipled straight," but note that there is a reversal between group "A" and group "B." All level marking circuits are wired to the vertical banks of group "A" in conformity with the stepping of the Strowger switch, i.e., the level marking conductor

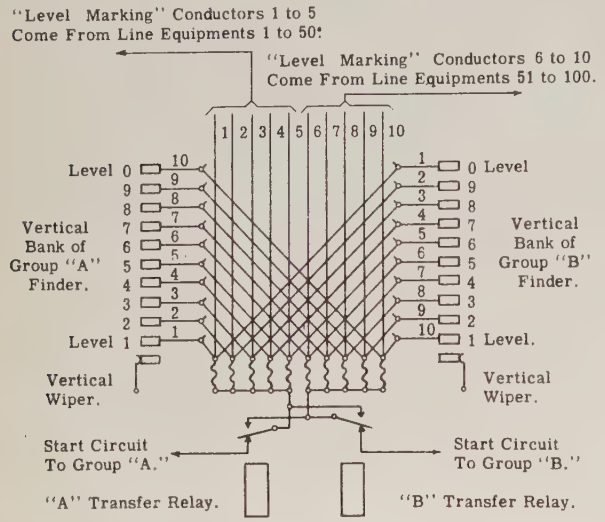



Fig. 1 - Level Assignment in Vertical Banks of Group "A" and Group "B" Finders.

which is common to line equipments 90 to 99 is connected to the ninth vertical bank contact, etc. It will be noted that the levels appear in reverse order in the vertical bank of the "B" finder group; i.e., the level marking conductor which is common to line equipments 90 to 99 is connected to the second vertical bank contact, etc.

A level marking conductor also serves as a "start" conductor, and it will be noted that the lower half of the line equipments ( 1 to 50) are associated with marking conductors 1 to 5 which pass through contacts of the "A" transfer relay to the group "A" start circuit. In a similar manner, the upper half of the line equipments (51 to 100) are associated with marking conductors 6 to 10 which pass through contacts on the "B" transfer relay to the group "B" start circuit.

Thus it will be seen that a line equipment is the lower half ( 1 to 50) will mark all vertical banks, but will start only the preselected "A" finder. In the same way, a line equipment in the upper half (51 to 100) will mark all vertical banks but will start only the preselected "B" finder.

So far, the only gain is that no finder need normally rise above its fifth level; this helps some, but it still remains that calls marked in the bottom level of either group will steal finders from calls marked in higher levels. If the traffic from the lower half of the line equipments ( 1 to 50) is heavy enough to make all group "A" finders busy, the "A" transfer relay will function to transfer its start conductor to the "B" group. The next call originating in the lower half of the line equipments (1 to 50) will start the preselected "B" finder - which may find it in the upper levels - providing there are no calls waiting in the lower levels to steal that particular finder.

206 (c) Dial Tone: One of the talking points used by that "you do not have to wait for an operator." The older Strowger system provided an "individual" first selector per line and of course there was no waiting. Then came Keith's preselecting plunger line switch, which still permitted one to dial as soon as the receiver was removed.

Dial tone was not generally used in Strowger offices until about 1928, then the extended use of finders made it imperative that the subscriber be given the now well known instruction:

> "Hold the receiver to your ear. You should hear the dial tone - a steady humming sound. This is your signal to start dialing. LISTEN FOR IT BEFORE DIALING."

207. Finder Connector Link: The words "tied tail to-tail" always seemed particularly apropos to the writer as descriptive of the association of a finder and connector or selector, because they are obviously headed in opposite directions. Be that as it may the Navy took exception to the phase as being meaningless. Since then technical literature prepared for Navy consumption has used the term "tied stern-to-stern."

208. Finder Distributor: Usually a mechanism and its associated relays are termed a "switch, i.e., connector switch, selector switch, etc." But in a discussion of finders, a distinction is commonly made between the "control (or group) relays" and the "distributor". The word "allotter" is sometimes used as an overall term descriptive of the assembly of relays and mechanism.

Each group of line-finders has a set of "group relays" associated with it, which control the action of the finders, and cause the distributor to operate and allot the next idle finder after a call has been picked up by the finder previously allotted. They also cause an alarm to be given in case of faulty operation.

The distributor may be considered an adjunct to the group relays, since it connects these relays successively to the finders of the group. As previously mentioned, an idle finder is pre-alloted by the group distributor.

The distributor may be either (1) a stepping switch or (2) an "all relay" group. The stepping switch is perhaps the easiest to understand, and will be used to illustrate this section.

The distributor is a rotary switch mechanism (Fig. which has access to a multi-level semi-cylindric bank containing twenty-five contacts in each lev A pair of double-ended wipers rotates over each le of contacts. The wipers are engaged with the ba

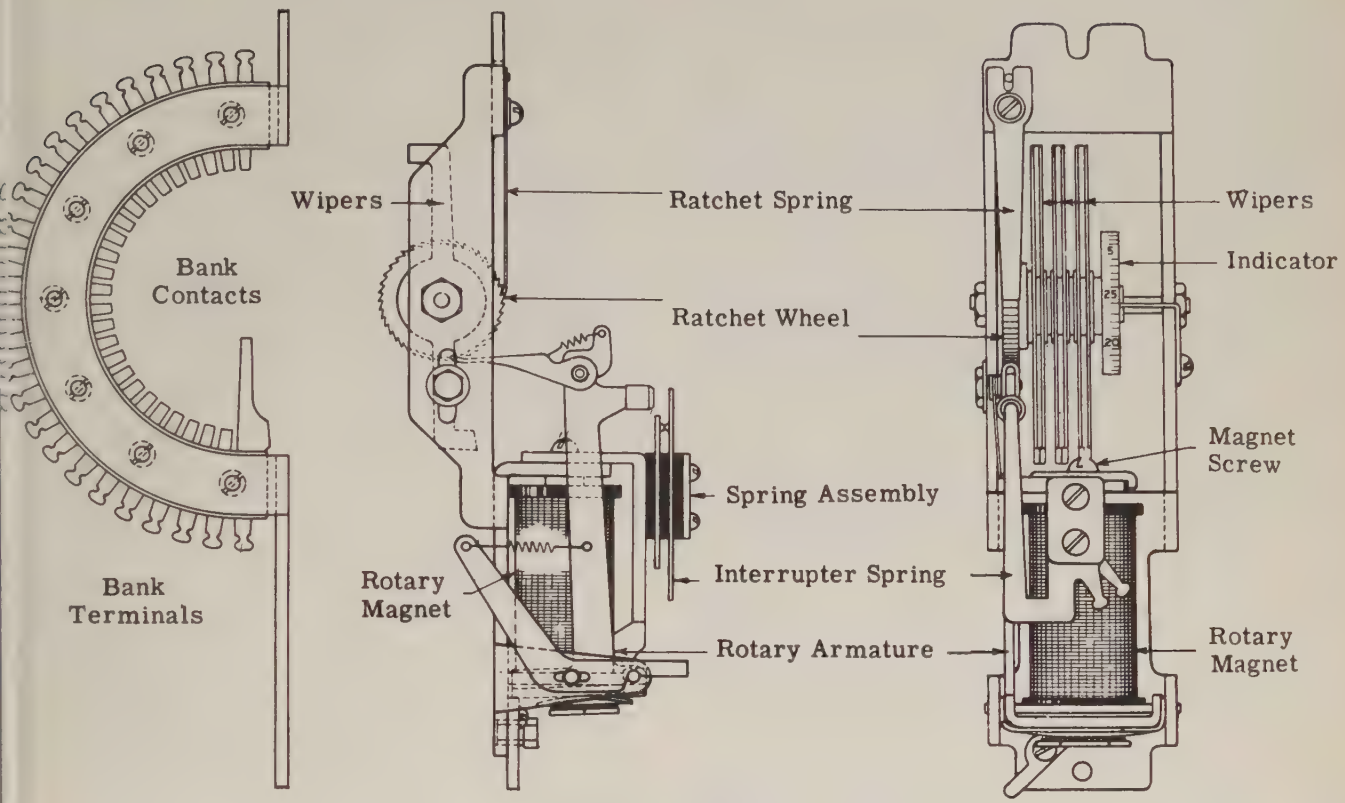



Fig. 2 - Rotary Switch Mechanism and Bank.

l times; that is, when one end of the wipers is ing position twenty-five, the other end is approach- osition one. By rotating through a half circle, the rs successively step over all twenty-five sets of acts.

driving mechanism comprises a ratchet wheel, nted on the wiper shaft, the ratchet being engaged pawl pivoted to the armature of a motor magnet. n the motor magnet is energized, the pawl is with- vn from the ratchet wheel so that it can engage next tooth when the motor magnet is deenergized. tractile spring, tensioned against the motor-mag- armature, causes the pawl to engage the ratchet h and step the wipers to the next position as the or magnet releases.

The 200-Line Finder: Let us now visualize a owger line-finder switch which retains the cus- ary ten vertical levels but which, when rotating, searches over twenty lines: that is, two lines are tested on each of the ten rotary steps. We now have a 200-line finder: and the system will consist of 200-line equipment, 20 finder-connector links and two distributers. Due to traffic reasons explained hereinafter the 20 finders are divided into two groups of 10 finders, designated groups "A" and "B." Each group is controlled by its own distributer.

209 (a) Preferential Hunting: Each 200-line finder bank assembly comprises three 200-contact banks and therefore accommodates 200 subscribers' lines, each being represented by three points on the whole bank. On the bottom bank are terminated the - and + line conductors of an "odd" hundred lines; on the middle bank are terminated the - and + line conductors of an "even" hundred lines, and the top bank contains the terminals of the 200 control leads associated with these lines. The lower contacts of each level of the control bank are associated with the lines

terminated in the lower line bank; and the upper contacts, with the lines terminated in the upper line bank.

This arrangement illustrates the actual (or numerical) grouping of subscribers' lines.

Many students have had difficulty in distinguishing between (1) the actual (or numerical) grouping of the subscribers' lines and (2) the "theoretic" grouping of "appearances" which makes "preferential Hunting" possible.

For our next consideration let us disregard the actual structure of the finder-switch, and visualize merely a Strowger switch which has access to ten levels and is capable of taking 20 steps in each level. (See Sec. 132 (e) for a switch that actually did this).

209 (b) We will now assume a theorteic "A" group of one hundred appearances (Fig. 1), and also a theoretic "B" group (Fig. 2) of one hundred appear-

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10TH LEV. | B81 | B82 | B83 | B84 | B85 | B86 | B87 | B88 | B89 | B90 | B91 | B92 | B93 | B94 | B95 | B96 | B97 | B98 | B99 | B00 |
| | B61 | | | | | | | | | | | | | | | | | | | B80 |
| | B41 | | | | | | | | | | | | | | | | | | | B60 |
| | B21 | | | | | | | | | | | | | | | | | | | B40 |
| 6TH LEV. | B1 | B2 | B3 | B4 | B5 | B6 | B7 | N8 | B9 | B10 | B11 | B12 | B13 | B14 | B15 | B16 | B17 | B18 | B19 | B20 |
| 5TH LEV. | A81 | A82 | A83 | A84 | A85 | A86 | A87 | A88 | A89 | A90 | A91 | A92 | A93 | A94 | A95 | A96 | A97 | A98 | A99 | A00 |
| | A61 | | | | | | | | | | | | | | | | | | | A80 |
| | A41 | | | | | | | | PREFERRED | | | | | | | | | | | A60 |
| | A21 | | | | | | | | APPEARANCES | | | | | | | | | | | A40 |
| 1ST LEV. | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 |

Fig. 1 - Theoretic Appearances in Banks of Group "A" Finders.

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10TH LEV. | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 |
| | A21 | | | | | | | | | | | | | | | | | | | A40 |
| | A41 | | | | | | | | | | | | | | | | | | | A60 |
| | A61 | | | | | | | | | | | | | | | | | | | A80 |
| 6TH LEV. | A81 | A82 | A83 | A84 | A85 | A86 | A87 | A88 | A89 | A90 | A91 | A92 | A93 | A94 | A95 | A96 | A97 | A98 | A99 | A00 |
| 5TH LEV. | B1 | B2 | B3 | B4 | B5 | B6 | B7 | B8 | B9 | B10 | B11 | B12 | B13 | B14 | B15 | B16 | B17 | B18 | B19 | B20 |
| | B21 | | | | | | | | | | | | | | | | | | | B40 |
| | B41 | | | | | | | | PREFERRED | | | | | | | | | | | B60 |
| | B61 | | | | | | | | APPEARANCES | | | | | | | | | | | B80 |
| 1ST LEV. | B81 | B82 | B83 | B84 | B85 | B86 | B87 | B88 | B89 | B90 | B91 | B92 | B93 | B94 | B95 | B96 | B97 | B98 | B99 | B00 |

Fig. 2 - Theoretic Appearances in Banks of Group "B" Finders.

ances; each group being served by a plurality of finder-selector links under the control of an associated distributor.

The one hundred "A" appearances occupy the lower five levels in the banks of the "A" group of line-finders, and are normally served by this group. The one hundred "B" appearances occupy the lower five levels in the banks of the "B" group of line-finders, and are normally served by this group.

Attention is directed to the fact that the levels appear in reverse order, for reasons which later will be apparent.

The one hundred "A" appearances also occur in reverse order of levels in the upper five levels of the "B" group of line-finders; while the one hundred "B" appearances occur in regular order of levels in the upper five levels of the "A" group of line finders. Thus it will be seen that the appearances although arranged in groups of 200 on the banks of the line-finder, are served in 100 groups under normal traffic conditions, each 100 group having its individual allotment of line finders. However, the 200 grouping is established whenever the traffic in a 100 group becomes abnormal and its allotment of line-finders i momentarily inadequate. The line-finders of th associated 100 group are then assigned (by means group distributer equipment) to serve the two 10 groups until the traffic in the overloaded group be comes normal.

The prime advantage of this arrangement of appear ance grouping is that the conductors of two associ ated 100 groups are so transposed in the banks of th line-finders that the line-finders of neither group ar required normally to hunt in the upper five levels This results in the establishment of a uniform an satisfactory minimum hunting time, reduces the pro ability of lines in the lower levels "stealing" a lin finder from lines in the upper levels to a negligibl factor in case of simultaneous calls; and insures th service to the group will continue even though on distributer should fail.

209 (c) We will now return to a consideration of th actual (or numerical) grouping of the lines in th finder banks.

Referring to Fig. 3, it will be observed that the num bering scheme actually employed in the finder bank of group "A" follows standard Strowger practice i.e., "one step up, and one step in" gives access t line 111 or line 211, depending upon which hundre is wanted, and likewise "ten steps up and ten step in" gives access to line 100 or line 200. The banks the "A" group of line-finders are multipled straigh that is, the contacts of one bank are connected to co

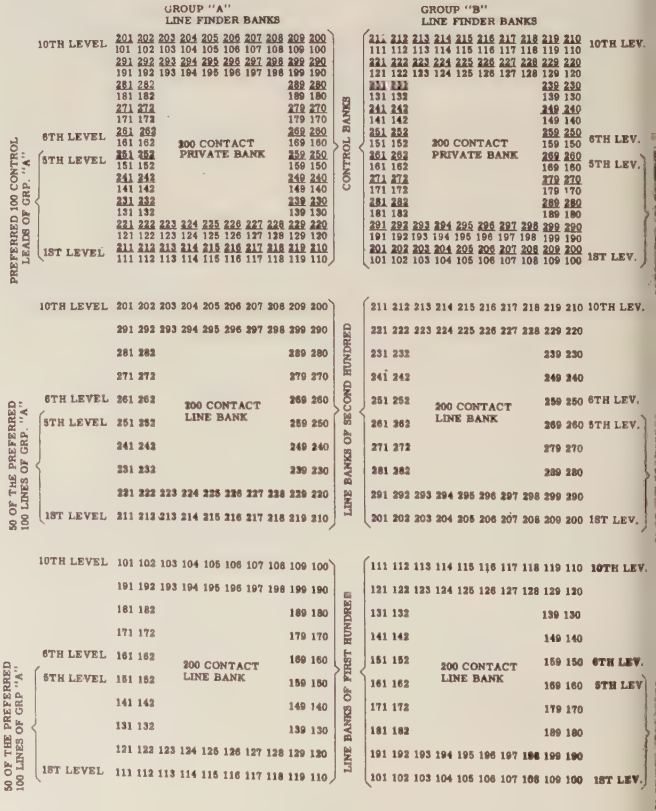



Fig. 3 - Actual (or Numerical) Grouping of Lines in Finder Banks.

tacts which occupy the same relative position in th next corresponding bank.

banks of the "B" group of line-finders are also piled straight, but it is to be noted that a vertical reversal is made in the multiple between the sections of the two groups; thus "one step up, one step in" gives access to line 101, or line 201, ading upon which hundred is wanted, and likewise steps up, and ten steps in" gives access to line or line 210.

w becomes apparent that the "A" grouping and grouping of appearances does not correspond the actual (or numerical) grouping i.e., the 100 group, and the 200 line group. In a previous graph it was said that the "A" group of finders ally served the 100 appearances occupying the five levels in its banks; from a study of Fig. 3 l be apparent that the "A" group of appearances rises fifty lines of the 100 numerical group 110, 121-120, 131-130, 141-140, and 151-150) ifty lines of the 200 numerical group (211-210, 20, 231-230, 241-240 and 151-250).

"B" group of appearances will be found to com- fifty lines of the 100 numerical group (101-100, 90, 181-180, 171-170, and 161-160) and fifty of the 200 numerical group (201-200, 291-290, 80, 271-270, and 261-260).

undamental principle of the 200-line finder is rated in Fig. 4. Here is indicated an "A" group

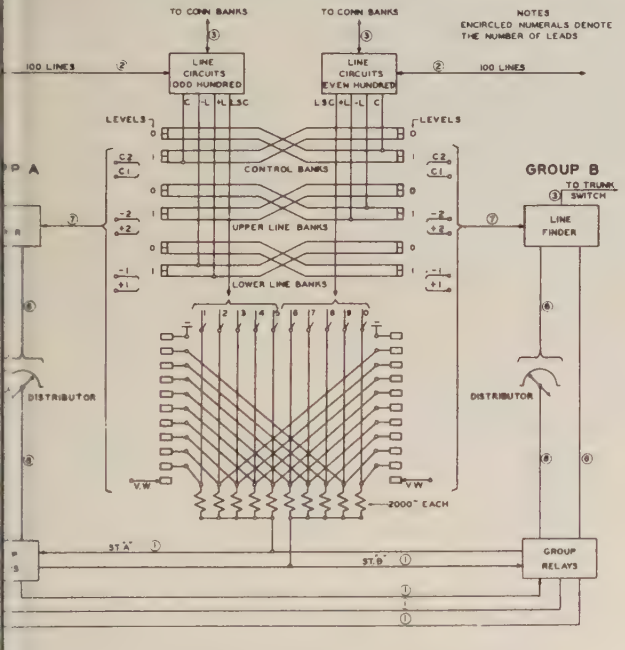



Fig. 4 - Key Diagram of the 200-Line Finder Unit.

ders and a "B" group of finders. The first ical group of line equipments (the odd hundred) wn connected to the lower line bank, while the numerical group of line equipments (the even ed) is shown connected to the upper line bank. 200 lines are, with respect to the multiple gement of the finder banks, divided into two 100- eoretical groups designated "A" and "B" hav- ividual allotments of finders. However, a 200- roup is established whenever the traffic in one of the 100-line groups becomes abnormal, and all its finders are temporarily engaged. That is, each group of 100 is normally served by its separate group of finders, which also assists in serving the other 100 group during heavy traffic periods.

Two relays comprise the equipment which is directly associated with each subscriber's line. They are comparable to those used in common-battery manual systems. With respect to the line-finding operations, the chief duties of the line relays are to "mark" the bank position of the line initiating the call and to cause the allotted finder to hunt the calling line.

For economy, each group of finders is operated under control of relays common to the group. This is possible, because the finders of each group operate one at a time.

Likewise associated with each line-finder group is a distributor which assigns the selector trunks successively to the originating calls. This distributor acts as a preselector, by allotting, after a call is picked up, an idle finder to the next succeeding call.

Immediately the finder banks are "marked", by the relay equipment associated with the calling line, a relay of the common relay group causes the allotted idle finder to hunt first vertically, and then horizontally until the calling line is located, whereupon the finder connects the associated first selector (or a connector in a small installation) to the calling line. When this switch is seized, dial tone is transmitted to the calling line.

Simultaneously with the switching through of the calling line to the trunk, a cut-off relay associated with the calling line operates to clear the line of attachments, and to disconnect the common start circuit. When the common relay group is freed, the distributor allots another idle finder of the group in readiness for the next originating call.

The individual bank terminal is marked by the line relay connecting "-" battery to the individual control lead C. The finder bank level in which the calling line is located, is marked by the line relay connecting ground to the "level start common" lead L. S.C. This same source of ground is connected, through a 2000-ohm resistance, to a common "start" lead, to cause a relay in the group circuit to operate and start a finder hunting the line initiating a call. Fig. 4 shows these resistances, and the method of connecting the "level start common" leads to the vertical bank contacts of the finders. It will be observed that when one of the vertical bank contacts has a direct ground potential connected to it, this source of ground is also connected to all the other vertical bank contacts, but through 4000-ohms. However, since the vertical hunting operation of the finder is controlled by a direct ground potential, the resistance of the ground connected to the vertical bank contacts, other than the one marked, is too great to interfere with this vertical searching.

209 (d) Mechanical Arrangement: In the foregoing discussion of fundamental principles, the components of the 200-line finder were introduced; namely the "line relays," the "line-finders," the group "distributor," and the "group relays." These four components operate in conjunction with each other, without action on the part of the calling subscriber other than the removal of the receiver from the hookswitch. Each component has certain definite functions to perform in the operation of the system as a whole. A brief description of their mechanical arrangement should be of material assistance in understanding the functions devolving on each of them.

209 (e) Line Relays: Associated with each subscriber's line is a combined "line," and a "cut-off" relay of the conventional Strowger type. When message rate service is rendered, a message register or meter, is also associated with each subscriber's line arranged for this service.

209 (f) Line-Finder: The line-finder proper is a two-motion Strowger switch, quite similar in appearance to the more familiar selector commonly employed in Strowger systems. It comprises a group of relays mounted on a base upon which also is mounted a frame supporting a shaft and a ratchet mechanism for raising and rotating the shaft. Affixed to the lower end of the shaft are four sets of wipers (one single-conductor and three two-conductor), termed the "lower line," "upper line," "control" and "vertical" wipers.

The vertical and rotary stepping magnets, and the magnet which releases the ratchet mechanism and permits the shaft to return to normal when the connection is released, are mounted within the switch frame.

A line-finder is a non-numerical switch; that is, both its vertical and rotary (stepping) motions are independant of dial control. The number of vertical steps the shaft and wiper rise, depends on the "marking" of the vertical bank, or commutator. The number of rotary steps the shaft takes depends on the position of the marked control bank contact in that level.

A vertical interrupter circuit causes the vertical magnet to elevate the shaft step-by-step to the "marked" level. Immediately the vertical stepping is completed, a rotary interrupter circuit causes the rotary magnet to rotate the shaft automatically until the marked control bank contact is engaged by the wipers.

These motions cause the three sets of two-conductor wipers to engage contacts of a semi-cylindrical bank. Referring to Fig. 2 Sec. 203, it will be observed that the bank contacts are arranged in three groups; the uppermost of the three is termed the "control bank;" the middle bank, the "upper line bank"; and the lower one, the "lower line bank." The multiple arrangement of these banks was described in Sec. 209 (c).

To the right of the semi-cylindrical banks is the ver ical bank, or commutator, comprising a single r of contacts. This vertical bank, and the associat wiper, enables the finder to locate the level of t line initiating a call, without the necessity of testi the individual bank contacts of the lower levels. T upper ten vertical bank contacts correspond to t ten levels of the semi-cylindrical banks, and the bo tom contact is a normal position for the wiper. Wh the shaft is being stepped vertically, the vertic wiper engages the commutator bank contacts. At t first rotary step, the vertical wiper disengages fro the bank.

The release of the shaft is accomplished by means a release magnet which, when energized, operates t "release" armature. This armature striking a pr jection of the double-dog, disengages both the ver ical dog and the rotary dog from the hub. The sha is then freed from the stationary dog, and drops normal.

209 (g) Group Relays: Each group of line-finder has a set of "group relays" associated with it. comprises a number of control relays mounted on baseplate equipped with a multi-contact jack.

These relays control the actions of the finders, a cause the distributor to operate and allot the ne idle finder after a call has been picked up by the fin er previously allotted. They also cause an alarm be given in case of faulty operation.

209 (h) Distributor: The distributor may be con sidered an adjunct to the group relays, since it con nects these relays successively to the finders of th group. As previously mentioned, an idle finder pre-allotted by the group distributor.

209 (i) Functions: The major functions of the var ous elements of the 200-line finder are outlined the order in which they occur. Some of these fun tions, however, will involve several elements.

209 (j) Line Relays:

A. Outgoing Calls: On outgoing calls the functions of the line relays are: (1) to mark the level in the commutator banks; (2) to mark the line in the control banks; (3) to cause the group relays to operate the allotted finder and (4) to free the line of attachments when the finder seizes it.

B. Incoming Calls: The only function of the line relays on incoming calls is to free the line of attachments.

209 (k) Line-Finder: The functions of the line finde are: (1) to elevate the wipers to the marked level; ( to rotate the wipers onto the terminals of the cal ing line; (3) to determine which of two lines is de manding service; (4) to connect the associated trun to the calling line; (5) to cause the cut off relay of th calling line to operate and clear the line of attach

ts; (6) to busy the calling line at the connector k; (7) to advance the group distributor; and (8) to ase at the termination of the call.

(l) Group Relays: The functions of the group re- are: (1) to seize the allotted finder at the initi- of a call; (2) to provide a pulsing circuit for the tical magnet of the finder; (3) to stop vertical ping of the finder when the vertical wiper en- s the marked commutator contact corresponding e level in which the calling line appears; (4) to ide a pulsing circuit for the rotary magnet of the r; (5) to cause the distributor to disengage from inder when the calling line is seized; (6) to ad- e the distributor to the next idle finder; (7) to fer the start lead to the adjacent group of finders se of faulty operation; and (8) to signal an at- ant if an associated finder fails to release.

m) Distributor: The functions of the distributor (1) to connect the group relays to any one of the rs of the group; and (2) to disengage from the tted line-finder when the calling line is seized, lliot the next idle finder of the group.

n) See STJ (Clare) 6-32 for discussion of the ine Finder using the Pye polar relay. For a lete discussion of a specific 200-Line Finder .E.Co. Bul. 821.

Strowger Selector: The expansion of a Strowger m beyond 100 lines introduces the use of one re selectors in a train between the subscribers' equipment and the connector switch groups, de- ng on the desired capacity of the system.

000-terminal system, only a single rank of sel- s is required, and the first digit causes the con- n to be extended to a connector serving the ed hundred line group. The selection of the ular line in the group (tens and unit selections) unction of the connector switch.

0,000-terminal system, two ranks of selectors equired; the first is operated by the first digit l, and selects a trunk to the desired thousand , each trunk terminating in a selector in the d rank. The latter is operated by the second and selects a connector serving the desired ed group, in the thousand group previously sel-

larly, in a 100,000-terminal system, the first or in the train will select the desired office comprising 10,000 terminals ultimate); the sec- lector; the desired thousand group in that of- nit; and the third selector, the desired hundred in the thousand group previously selected.

lector has two main function -- group choos - d trunk selection. The former is under the l of the subscriber, because it corresponds to in the call number. The trunk selection is matic, because it makes no difference to the subscriber which trunk he seizes provided it leads to the group desired.

Trunk selection involves three elements: (1) "cut-in," (2) automatic rotary, and (3) stopping on the first idle trunk; all of which must be accomplished within the time required to dial the next figure, even though it be a "1".

210 (a). Cut-In: The "cut-in" is one of the sequential operations, see Sec. 205 (c), and is determined by the fall-away time of a slow-to-release relay which remained energized during the dialing of the group-choosing digit. It may be mentioned, as a matter of historic interest, that the early selectors did not have "automatic selection of trunks," since there was only one contact in each of the ten levels. The switch cut-in on the level dialed and, if the trunk was idle, the call got through; if not, if did not.

210 (b). Automatic Rotary: A motor magnet, directly interrupting its own circuit, will produce a fast rotary motion which is likely to be ragged. If the interrupter springs are set to "break early" the armature never comes flush up against the pole face; if set to "break late" the armature never fully restores.

In the old "three-wire" days, a toggle action was used to insure complete movement of the rotary armature, see Sec. 335 (c) (B). The B.P.O. switch also makes use of a toggle action, see A.E.Co. Bul. 356, Sec. 211. Modern American practice has secured a smooth rotary by having a relay play tag with the motor magnet, see AT 10-19.

210 (c) Searching for Absence of Ground: The older practice was to protect busy trunks by grounding their private bank contacts, while all idle trunks had neutral private contacts, or, in some special cases, the private contacts were normally connected through a resistance to negative battery.

Those who objected to the older scheme pointed out that a call would be lost should a selector strike a trunk with an open private conductor. This is perhaps a good argument if used in connection with poorly maintained unattended offices.

210 (d) Battery Searching: A battery searching selector, instead of searching for the lack of a certain potential, searches for the presence of a particular potential on the private bank contact, i.e., negative battery. Thus, a battery searching selector will pass over a trunk having an open private conductor. But how about an open line conductor? As there are twice as many line conductors to go open as there are private conductors, why strain for the gnat with battery searching?

210 (e) Stopping on the First Idle Trunk: The unforgivable sin is to design a selector which will stop on a busy trunk (and there have been some in Strowger practice); the next worst thing is to "skip idle trunks." At one extreme is a slow rotary which is absolutely sure, at the other is a fast rotary which occasionally

gets into trouble; a compromise should be made somewhere in between.

There are three ways of stopping the rotary action when the first idle trunk is reached: (1) by the de-energization of a relay (which was held up so long as the private wiper engaged grounded bank contacts); (2) by the energization of a relay; and (3) by locking either up or down, the "tag" relay that plays with the motor magnet.

210 (f) In both the 3-wire, see Sec. 335 (e) (D), and the early side-switchless 2-wire selectors, the stopping on an idle trunk was dependant upon the de-energization of a relay. If the relay springs were too stiff the selector might stop on a busy trunk, and if the relay springs were too weak the selector tended to pass over idle trunks. If certain of the private bank contacts were normally connected through a low resistance to negative battery, the relay would be shunted and made slightly slow-acting so as to fail to de-energize quickly enough to allow the selector to "cut-out" on the first idle contact. See AT 10-19.

210 (g) Saunders, writing in STJ 12-32, describes a battery searching selector wherein a Pye polar relay snaps up on the first idle trunk in time to stop a self-interrupting motor magnet. Bakker, in STJ 12-38 describes a similar system using an ordinary relay to stop the rotation.

210 (h) Powell, in 1914, designed the first fool-proof selector, which has become the basis for all good "automatic rotary" circuits. For the purpose of this section, we may merely visualize a "tag" relay closing the rotary magnet circuit and the rotary magnet opening the tag relay circuit. In this way, a reasonably fast and smooth rotary action is obtained. The tag relay is purposely made inefficient so that it will not operate in series with a switching relay. So long as the private wiper is passing over grounded private bank contacts, the ground thereon shunts out the switching relay. The switch is stopped dead on the first idle trunk because the tag relay cannot again energize. The switching relay, however, energizes in series with the tag relay to "cut-out" the selector.

210 (i) The 10/20 Selector: The 10/20 selector retains the customary ten vertical levels, but when rotating, searches over twenty trunks; that is, two trunks are tested on each of the ten rotary steps.

210 (j) The major functions of the selector, in the order in which they take place; are: (1) Immediately upon seizure, to hold all preceding switches in the train operated and guarded until the holding (control) circuit is completed to the next (succeeding) switch in the train; (2) if it is a unit in a first selector group, to connect dial-tone to the calling line; (3) to elevate the shaft and wipers in response to the impulses from the dial; (4) to find and connect with an idle trunk in the selected bank level (rotary motion). This rotary motion comprises seven functions: (a) To rotate the shaft automatically; (b) to keep the line wipers disconnected during rotation; (c) to test each trunk successively; (d) to stop the rota movement at the first idle trunk; (e) to protect trunk selected until the holding (control) circuit completed to the next (succeeding) switch in t train; (f) to extend the lines through to the next (su ceeding) switch in the train; and (g) to disconnect bridges or attachments from the transmission ci cuit; (5) to provide an audible busy signal to the ca ing person when all trunks in the selected level a engaged; and (6) to release without interfering w other trunks when the calling person restores t receiver to the hookswitch.

210 (k) For a complete discussion of a specific se ector, see A.E.Co. Bul. 808.

210 (l) Digit Absorbing Selector: A digit-absorbi selector operates like any selector except when digit to be absorbed is dialed. The selector rais its shaft to the dialed level, but at that point a norm post spring assembly causes the selector to releas Subsequent digits dialed, including a repetition of t one just absorbed, will cause the selector to opera in the standard manner.

211 Impulse Repeater: There are three princip reasons for using impulse repeaters on interoffi trunks.

The first is a matter of economy, through the elim ination of the third wire (control circuit) from th inter-office trunk, and consequent reduction in e pense for wire between the offices. The repeate accomplishes this by maintaining a ground on t control circuit to all preceding switches in the train

The second is related to transmission. Since t performance of a telephone transmitter depends part on the amount of direct-current flow, it is de sirable to restrict the distances over which trans mission current is supplied. This is accomplishe on inter-office trunk calls by supplying transmissi current to the called person from the connecto switch in the terminating office, and to the callin person from the repeater in the originating offic The efficiency of transmission on inter-office cal is,therefore, much higher than if transmitter curre were supplied to both parties from the connector.

The third concerns the repeating of impulses. Wit out an impulse repeater, the impulse circuit to t distant switches would have to include both the lin circuit of the calling telephone and the inter-offic trunk line. In many cases, the effect would be to s weaken the impulses that they would fail to operat the switches in the terminating office. Then, too, th local office battery is insulated from the trunk b condensers. For these two reasons, the impulse from the calling dial must be relayed, or repeate to the trunk. Thus, the line circuit of the callin telephone is eliminated from the impulse circuit fo operating the distant switches.

Two types of impulse repeaters are in general us namely, "one-way" and "two-way" repeaters.

(a) One-Way Impulse Repeaters: The one-way ulse repeater is used to trunk calls from one ce to another, in one direction (outgoing) only. h a repeater is located in the office from which calls proceed. The two terminations of the inter-ce trunk are known as outgoing and incoming, pectively; outgoing in the originating office, and oming in the terminating office.

(b) Functions: The major functions of the one-impulse repeater are outlined below in the order hich they occur: (1) to ground the control lead rder to hold all the preceding switches in the rn operated; (2) to make itself busy against seiz-l by other calls; (3) to close the trunk loop to the ceeding switch in the distant office, and to repeat ulses to the switches in the distant office train; to reverse the polarity of the current supply to calling telephone when the polarity of the current ply to the repeater over the inter-office trunk is ersed by the operation of the connector in the ant office; (5) to supply transmission current to calling telephone; and (6) to allow all the switches lved in the connection to release when the re-er at the calling telephone is restored to the switch.

(c) Two-Way Impulse Repeater: A two-way im-se repeater makes possible "two-way" operation nter-office trunks, thereby realizing consider-economy in trunk cable facilities between offices. ere two-way trunking is employed, a repeater of type is located at each end of the inter-office nk.

circuit of a two-way impulse repeater is similar nat of the one-way repeater, with the addition of a itching relay, designated "G." Normally, each -way inter-office trunk is connected at both ends n incoming selector, through, break contacts of ay G. When the trunk is seized at one end, the oming selector associated with the repeater at end is disconnected from the trunk, by the opera-of relay G.

outgoing calls (calls from the originating office to stant office), relay G will function to disconnect incoming selector from the trunk, in order to r the trunk of attachments at the originating ce, and the repeater is connected to the trunk ugh make contacts of relay G.

calls incoming from a distant office to the office hich the repeater under discussion is located, the nk is normally connected to the incoming selector onnector, through break contacts on relay G. Up-eizure of the incoming selector, ground is con-ted to the control lead (c), by the selector to make trunk and associated repeater busy to outgoing s.

ay G is slow to release, so that on outgoing calls incoming selector or connector in the distant ce will be released before the selector or con-or associated with the repeater at the originating office is reconnected to the trunk. This is to prevent "locking-up" the distant office switch train, due to the reversed polarity of battery connected to the trunk at the connector, in case the called person disconnects last.

211 (d). For a complete discussion of a specific impulse repeater, see A.E.Co. Bul. 810.

211 (e). Selector Repeater: In AT 5-21 it is stated, "Occasionally there is found an inter-office trunk so long that, even with an impulse repeater at the originating end, the high resistance of the trunk imposes conditions of operation on the line relays of the distant switches that are too severe for safety. To care for this, the selector at the distant end of the trunk is equipped with a set of repeater relays which are especially adjusted to receive impulses over a long loop, and to translate them into impulses closely approximately those originated in local lines."

211 (f) Switching Selector Repeater: Central offices of an automatic multi-office exchange area are generally interconnected by groups of direct trunks, the trunks originating in first selector banks. Sometimes, however, it is desirable to depart from this plan. A comparatively small office may be located on the outskirts of an exchange area to secure a more economical outside cable plant layout than could be secured by connecting the local lines directly to the nearest large central office.

To provide a separate group of trunks from such an office to each of the other offices in the system would be a poor plan, because each group of trunks would be comparitively small resulting in low trunk efficiency. A better arrangement, insofar as the outside plant is concerned, is to carry all of the originating traffic from this branch office to the nearest central office and from there to distribute it to the remaining offices over the same trunks which carry the traffic originating in that office.

This means that the branch office first selectors must be located in the central office, so that the trunks to other offices can be selected after dialing the first digit. As far as the outgoing traffic from such a branch office, known as a satellite or a suboffice, is concerned, this could be done simply by inserting a repeater in the outgoing line switch trunks and extending the trunks through the outside cable to first selectors located in the central office.

Since with this simple scheme the first digit dialed by a suboffice subscriber operates a switch in the central office, it is evident that should the called subscriber also be located in the suboffice, it would be necessary to use a second trunk leading back to the suboffice to complete the connection.

211 (g). In order to avoid using two trunks between a central office and a suboffice for completing a local call between suboffice subscribers, a switch known as the "switching selector-repeater" is used. This switch makes possible a connection between two sub-

office subscribers without holding an inter-office trunk for the entire period of a call.

As the name implies, the switching selector-repeater combines the functions of both a selector and a repeater together with a means for switching from one to the other in a single mechanism. It serves as a repeater on calls to other offices, and as a selector on local calls.

When a subscriber in a suboffice equipped with switching selector repeaters originates a call, the switching selector repeater, and outgoing secondary line-switch operate to extend the connection to a first selector in the central office. The switching selector repeater, being included in the primary trunk, operates as an ordinary repeater to relay the dial impulses to the interoffice trunk.

If the call is for a number not in the same suboffice, the switching selector repeater retains its function as a repeater throughout the building up of the connection. In the event, however, that the call is for a subscriber in the suboffice, the switching selector repeater will, as soon as the determining digit is dialed, rotate its wipers onto the required bank level, switching the connection through its bank to a local switch. The trunk loop to the central office will be opened, thus permitting the switches which have been operated there to restore, releasing the outgoing secondary lineswitch in the suboffice, and completely freeing the inter-office trunk. From this stage on, the connection is established by means of switches located wholly within the suboffice.

211 (h). Three types of switching selector repeaters have been designed with respect to the digit which distinguishes between local and interoffice calls: (1) where no other numbers in the system begin with the same digit as that of the suboffice, the first digit is distinctive and a first-digit switching circuit is used; (2) where other numbers in the system begin with the same digit as the suboffice numbers, second-digit switching circuits are employed; and (3) where other numbers in the system begin with the same first two digits, third-digit switching circuits must be used.

Which of the three types of circuits is employed depends on the size of the telephone system and on the block of numbers reserved for the suboffice.

In a five-digit system, numbers are generally reserved in blocks of 10,000 for central offices thus making the first digit an office selecting digit. Blocks of 1000 lines may then be assigned to suboffices, and hence, the second digit is commonly used to distinguish between a central office and its suboffice.

211 (i). For a second-digit type switch, the function of the switching selector repeater is determined by the first digit if that digit be assigned to an office other than the one associated with the suboffice; the switch will then function normally as a repeater. When the first figure dialed is that assigned to the divided office, the method of operation is not determined until the second digit. Should the second di belong to the suboffice, the functions of the switch v become that of a selector.

It should not be inferred that the switching selec repeater is useful only in a system embodying a nu ber of central offices. This is not the case; it just as applicable to a system consisting of one ce tral and one branch office.

211 (j). Functions: The major functions of switching selector repeater are: (1) to act as a r peater; (a) on calls to distant offices; and (b) on ca to the associated central office; (2) to act as a s ector on calls within the suboffice; and (3) to prov for connecting discriminating tones to the trunk wh desired, etc.

211 (k). For a complete discussion of a speci switching selector repeater, see A.E.Co. Bul. 8 also see AT (Clark) 8-19 and AT (Ray) 1-23.

211 (l) A True "Two-Way" Impulse Repeater: T impulse repeater described in section 211 (c) r peats impulses in one direction only and should r be called a two-way repeater. It is a one-way r peater (i.e., repeats impulses in one direction on adapted for use on a two-way trunk. The Bakk Patent No. 2,200,817 shows a true two-way repeat described in the following words:

"In Fig. 1 are shown three possible trunking schem adaptable for use between two automatic telepho exchanges. The scheme shown in Fig. 1A is illu trative of the use of a simple repeater as shown the Martin Patent No. 1,260,424. The object of t repeater as there used is to eliminate the third co ductor between exchange A and exchange B. It evident that this is a one-way repeater and repea impulses only on "out" calls.

"The scheme shown in Fig. 1B is illustrative of t use of two-way trunks between automatic exchange and in general conforms to the trunking scher shown in Lomax Patent No. 1,735, 328. Even tho the trunk is used in both directions, it is still ev dent that the repeater is a one-way repeater and r peats impulses only on "out" calls.

"Aside from the mere elimination of the third inte office conductor, repeaters are found to be of val in the matter of impulse correcting, as shown Lomax Patent No. 1,521,821. It follows then that th two repeaters of Fig. 1B might have incorporat within them certain impulse correcting feature Attention is called to the fact that any correcti made by the repeater in Fig. 1B can only compensa for the condition of the dial, and line leading to repeater. No compensation can be made for tru conditions as this is a one-way repeater.

"In Fig. 1C are shown two small exchanges emplo ing finder-connector links for setting up connectio as shown in Saunders Patent No. 1,999,788. The t exchanges are connected by a two-way trunk term

ng in each exchange upon the "two-way impulse ecting repeater" which forms the subject of this ntion. It is to be noted that the repeater repeats lises both on "out" and "in" calls. It is further e noted that impulse correction is made by the repeater for dial and line conditions, and by the nd repeater for trunk conditions, thereby, pre- ing greatly improved pulses to the switches of the ant exchange."

Trunking Within The Office: The trunking me shown in Fig. 3 Sec. 112 would not be al- ther satisfactory because, as the traffic on any n level become heavier, each selector would rch further and further on that level to find an trunk. Keith's "trunk slip" was invented to ten the time necessary for a selector to find an trunk, to reduce the possibility of two selectors ing the same trunk and to equalize the wear on switches ahead by distributing the work. There two places at which the trunk slip may be applied, e bank multiple, or in the multiple between bank inals of the shelves.

(a) Bank Slip: The retrograde bank slip Fig. 1, at one time in general use in Strowger offices.

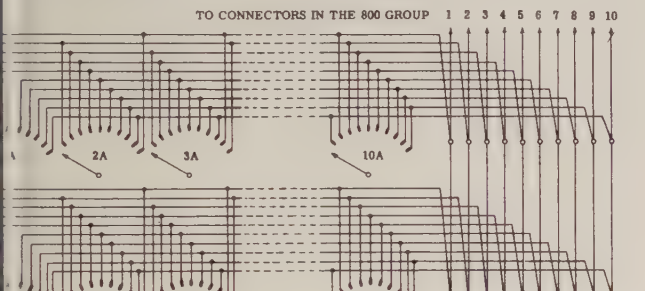



Fig. 1 - Retrograde Slip in Bank Cable

first bank is wired straight, bank 2 is wired with trunks in the same order, but slipped one step x. By this means, the first choice of each switch made to be the trunk whose number corresponds the number of the switch in the shelf.

s scheme was discontinued largely because of high manufacturing cost. When the banks are tipled "straight," the wires may be "skinned" machine, because the spacing is uniform. But the ip" necessitates non-uniform spacing, which ns hand skinning and high cost.

(b) Slip Between Shelves: The banks shown in . 2 are multipled straight, but it will be noticed there is a retrograde slip of one between the ives.

(c) Grading: When the theoretical number of nks required to carry the traffic from a level of shelf of selectors, or several shelves multipled ether, as described in the preceding paragraph, eeds ten, a form of multiple arrangement known "graded multiple" or simply "grading" is em- ployed. Grading is a method of associating a number of selector bank groups (shelves of 10) together in the terminal assembly so that the trunks from the levels are multipled in a manner giving certain shelves access to individual outgoing trunks from the lower numbered contacts, but on the higher numbered contacts these same shelves share access to trunks with other shelves. Thus, "individual" trunks are usually assigned to each shelf, "partially common" trunks to more than one shelf (but not to all shelves) and "common" trunks to all shelves. The result of this is that the trunks "hunted" over first serve a minimum number of shelves, while those trunks "hunted" over last are multipled on more, or all, of the shelves.

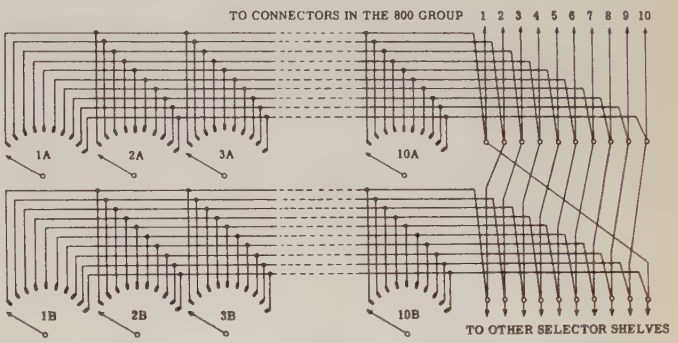



Fig. 2 - Retrograde Slip Between Shelves.

Therefore, if ten trunks were assigned to one selector shelf for a particular level, or to several shelves connected in "straight" multiple, the shelf or shelves involved could be checked as a unit. However, as the "straight multiple" arrangement is seldom used, it is fairly certain that the average selector level will not be multipled so as to provide trunk outlets wholly in groups of 10, but to provide for individual outlets scattered throughout the level; i.e., the multiple is graded.

In Fig. 3 are shown certain individual trunks and a group of common trunks, the latter, however, consisting of ten trunks which are given a slip between the different shelves, although only a fraction of the total number of common trunks are used on any one shelf. By this means thirty trunks are made avail-

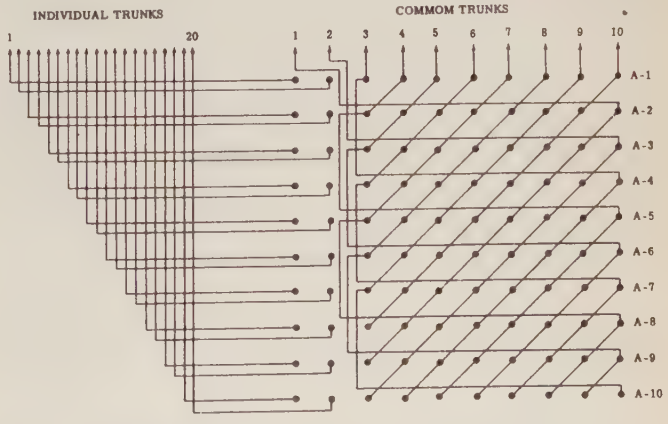



Fig. 3 - Illustration of Grading. 30 trunks made available to 10 shelves of selectors.

able to ten shelves of selectors. Looking forward, the wording would be, "the out-trunking from 100 switches (ten shelves of ten switches each) is increased from ten trunks to thirty trunks."

212 (d) Terminal Assemblies: The rapid growth of Strowger exchanges and the constantly changing traffic requirements for the communities served by them necessitate frequent additions, rearrangements, and re-grouping of trunking equipment within the telephone exchanges. To facilitate such additions and rearrangements of trunking, the "selector distributing terminal assembly" is used. A greater degree of flexibility in trunking is obtainable by its use than by the "flat type terminal assembly" formerly used.

The selector distributing terminal assembly permits the application of the principles of cross-connecting (as used on the M.D.F. and I.D.F.) to the trunk boards on which the selectors or trunking switches are mounted. It has the added advantage of providing means of multipling the sets of banks of the selector switches, either straight or graded, by strapping terminals on the front of the terminal assembly with short lengths of insulated wire. The back of the distributing terminal assembly is used for terminating the wires from the selector banks and for cross-connecting between the selector bank terminals and the outgoing cables by means of three-conductor jumper wire.

The terminal assembly consists of a number of horizontal rows, each consisting of ten bakelite blocks. Each horizontal row is connected to the bank wiring of one selector section. Each block, for terminating the wires of one bank level, contains thirty pins arranged in three horizontal rows of ten terminals each. The terminal pins of each block are so staggered that no two pins may be in the same vertical line. The upper ten pins are used for terminating the "positive" wires of a bank level, the middle ten the "negative" wires and the lower ten the control wires, or release trunks, associated with the ten positive and ten negative wires.

212 (e) For a detailed discussion of flat type terminal assemblies see AT (Clapham) 8-20, and AT (Clapham) 1-21. A historic treatment of terminal assemblies will be found in AT (McElyea) 9-24. The distributing type terminal assembly is discussed in AT (Walker) 3-25. For method of making additions to Automatic offices see AT (Ricksher) 5-19.

212 (f) For a complete discussion of the general subject of trunking see A.E.Co. Bul. 811; for trunking between community exchanges see A.E.Co. Bul. 819; and for Sigo's Multiple Pen Recorder, as used for traffic observations, see A.E.Co. Bul. 368, and AER (Axelson) 9-35. For an excellent article on Graded Multiple Theory, see Bell System Technical Journal (Wilkinson) 10-31. For calculation of switch quantities see A.E.Co. Bul. 2011, AT (Mitchell) 7-20, and AT (Bear) 11-20.

212 (g) In the fall of 1919 some forty equipment e gineers, representative of the various Bell operatin companies, attended a Step-by-Step school in Chicag sponsored by the A.T.&.T. The writer was the in structor and, as Perkins remarked, it was largely matter of the blind leading the blind, for the write was not then and never has been an equipment engineer

Some brass hat A.T.&.T. man was executive office of the school and, while the years have dimmed ou memories, there are a few points worth recalling.

On the very first day, the b.h. suggested, "Don' waste time trying to sell them on the alleged ad vantages of Step-by-Step; merely aquaint them wit the apparatus that they are to use."

In our study of trunking we made use of the Norfol terminal assemblies, which were pretty terrible The installation was complete and the exchange cu into service, but the drawings had not yet been brough up to date. The students were good, and they picke up numerous errors, only to receive the comment "yes that is an obvious error, which doubtless wa corrected by the installer." After this had happene seceral times, one student asked, "What kind of in stallers does A.E.Co. have? A W.E.Co. installer un der similar circumstances would sit on his tail unti Hawthorne told him what to do." The instructor re plied, "That is easily explained, Jim Murray was th installer at Norfolk and he knows more about engin eering than do most engineers."

When it came time to study "Calculation of Switc Quantities" the b.h. said he wanted first to present the A.T.&T. method, which took a whole day. The next morning the writer was reluctently permitted t present the A.E.Co. method, which required perhap two hours.

The instructor then had a happy thought and said "Here are data covering a proposed office. Suppos those in the North half of the room work it out acc ording to the A.T.&T. method, while those in th South half work it out according to the A.E.Co method." The results were about the same, but th South half of the room had most of the afternoon off.

213 Inter-Office Trunking: Inter-office trunking i no more difficult to lay out on paper than is trunkin within the office. With your back to the distant of fice, you merely say, X trunks must come in here to carry the busy hour load, and they must originate in the banks of Y selectors. How best to do it?

But, looking forward from a given selector raised t a certain level, you see only ten outlets, some being individual to that shelf and some being used in com mon with other selector shelves. It follows then tha the incoming load to this particular selector shel must not be too heavy or overflows will result. Com plicated, isn't it? That is why Sigo worked up hi Multiple Pen Recorder and his system of traffic ob servations, A.E.Co. Bul. 368.

(a) Outgoing Secondary Line Switch: It some-es happens that economies can be secured by nging into one group all the trunks from one of- to another. To secure this end, outgoing secon- y line switches are interposed between the first ector banks and the outgoing trunks in the origina- office. The trunks from any given shelf of first ectors are distributed among several shelves of ondary line switches in order that each shelf of tselectors may have access to all the trunks ring the office. In this way the several groups of nks leaving the secondary line switches become in a common group. In case any one shelf becomes sy, the traffic will be carried by the remaining ives and each shelf of first selectors will have one trunk made busy. Are you there, Charley?

y little has been written about the actual trunking d in metropolitan areas, probably for two reasons. st, no operating company likes to have its more ess dirty linen washed in public, and second, two y words are required to adequately describe a network. If the reader can get hold of a first, ond or third edition of this text he will find some en pages devoted to trunking as used in the old Paul - Minneapolis network. Many ingenious emes are shown herein, and it represents about s in Strowger trunking prior to the introduction of Director.

(b) The Director: In large metropolitan areas, it esirable to identify each subscriber's station by ns of an office name and four digits. To call a ired station it is necessary to "spell" the first (or three) letters of the office name by succes- turns of the dial, after which the four digits of call number are dialed in the usual way. It is ap- ent, therefore, that the dial must be marked with ers in addition to the digits. An example is shown ig. 3, Sec. 102(d).

rder that existing office names may be retained, s often necessary to disassociate the numbering eme and the trunking scheme. This may be ac- plished by means of the Director, as arrange- nts are provided therein to register the impulses responding to the two (or three) letters of the of- name, together with the digits of the call number, to send out other impulses of such number and bination as are required to extend the call, link ink, over the proper trunk routes.

designed by Nelson, a director consists of an e register in the form of the usual Strowger two- ion switch; a sending switch which takes the form rotary line switch motor mechanism and bank; a uence switch similar in form to the sending ch; and five minor switches. The first four minor ches are termed digit registers, while the fifth is aster digit control which operates to extend the ulsing circuit to each register in turn.

Referring to Fig. 1, note that a relay group has n inserted in the trunk to a first selector. When trunk is seized an associated line switch gives access to a director. A line relay in the group, thru the agency of the master digit control switch, causes the operation of the various registers in accordance with the dial impulses. At the time that the trunk is seized, a second relay in the relay group closes a circuit to the first selector. The sending switch controls this relay in such a way that the proper train of impulses will be sent out. When the last impulse has been sent, the relay group switches thru, thus freeing the director and making it available for use in setting up other connections.

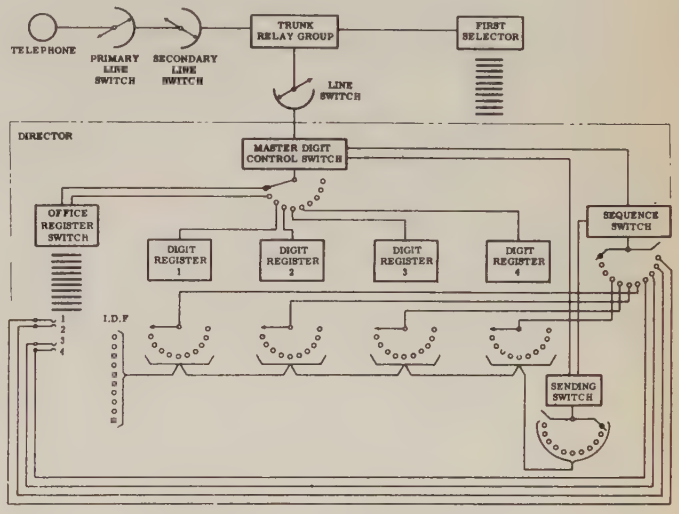



Fig. 1 - Scheme of Director.

Let us assume that the connection has been extended to a director and that the calling subscriber dials the number MAin 2345. When the letter M is dialed, the master digit control is in first position and the operating circuit extends thru the vertical magnet of the office register, and, as a result, the shaft and wipers 1 to 4, inclusive, will be raised to a position opposite the sixth level of bank contacts. The master digit control then steps to second position and switches the operating circuit to the rotary magnet of the office register.

When the second letter A is dialed two impulses will be produced which rotate the shaft and wipers into engagement with the second set of contacts in the sixth level. The master digit control then steps to third position and switches the operating circuit to the first digit register.

When the digit 2 is dialed the first digit register advances its wiper two steps. The master digit control then switches the operating circuit to the second digit register. The second, third and fourth digit registers are operated in a similar manner, each taking up a position in accordance with the corresponding digit in the call number.

The relation between the calling office and the called office is determined by a consideration of the trunk routes. In this case, we will assume that impulses corresponding to the digits 543 2345 must be delivered to the switches in order to extend the connection to the station represented by call number

MAin 2345. Note the difference between the first parts of these two numbers. The "MA" is part of the directory number of the called station. When the subscriber dials these two letters, the director must translate the two sets of impulses into the three sets represented by "543." which correspond to the path over which the connection must be extended to reach the terminating office. Hereinafter these translated impulses are referred to as the "code." The following will show how the translation is accomplished.

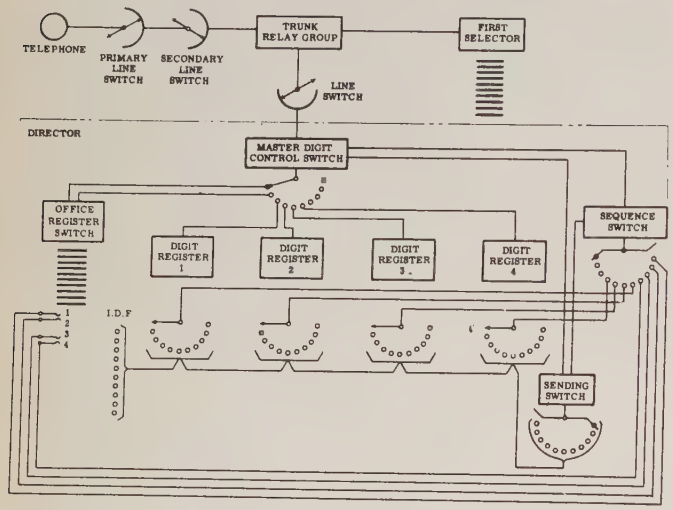



Fig. 1 - Scheme of Director (Repeated)

An I.D.F. is provided with ten terminals. These terminals, together with the contacts in the banks of the digit registers, are in multiple with the ten contacts in the bank of the sending switch. Since it is necessary to send the code 543, the contact upon which the No. 1 wiper of the office register is now standing is jumpered to the fifth terminal at the I.D.F. The contact upon which the No. 2 wiper is standing is jumpered to the fourth terminal, while the contact upon which the No. 3 wiper is standing is jumpered to the third terminal. As the code consists of only three figures we do not need the fourth wiper, and the contact upon which it is now standing is, therefore, jumpered to a special terminal.

When the operation of the office register is complete the sequence switch is stepped to first position and, as a result, ground is placed upon the No. 1 wiper of the office register, thereby grounding the fifth contact in the bank of the sending switch. The sending switch now starts rotating under the control of an interrupter and at each step causes a momentary opening of the impulsing circuit. When the grounded contact is reached a total of five impulses have been delivered to the first selector; the impulsing circuit is now permanently closed and the sending switch, by means of a buzzer action, rapidly rotates to normal position.

When the sending switch returns to normal the sequence switch advances to second position and, in so doing, grounds the No. 2 wiper of the office register; thereby grounding the fourth contact in the bank of the sending switch. The sending switch now rotate and transmits a series of four impulses to the secon selector, after which it advances to normal and th sequence switch steps to third position.

The No. 3 wiper of the office register is now ground ed, as is also the third contact in the bank of th sending switch. The sending switch now rotates an transmits a series of three impulses to the thir selector, after which it advances to normal and th sequence switch steps to fourth position.

In the case under discussion, we do not need a fourt digit in the code; therefore, the contact upon whic the No. 4 wiper is standing is jumpered to a termina which causes the sequence switch to step to fift position, no movement of the sending switch takin place at this time.

When the sequence switch steps to fifth position, th wiper of the first digit register becomes grounde and, since it is standing on the second contact in it bank, ground is placed upon the second contact in th bank of the sending switch. The sending switch no rotates and transmits a series of two impulses to th fourth selector, after which it advances to norma and the sequence switch steps to sixth position

In a like manner the sequence switch in turn extends the circuit to the second, third, and fourth digit registers; and as a result the sending switch sends a series of three impulses to the fifth selector, and a series of four impulses followed by a series of five impulses to the connector. Upon the completion of the operation the relay group switches thru and frees the director. All of the switches within the director now return to normal position.

In case only two digits are required in the code, the contact upon which the No. 3 wiper of the office register is standing is jumpered to a special terminal which causes the sequence switch to advance thru the third position without causing an operation of the sending switch. If the director were to be used in a system requiring the dialing of three letters, a director selector would be interposed between the relay group and the director. The first letter of the call number would then cause the director selector to pick out an idle director in the group determined upon by the letter dialed.

From the preceding, it can be seen that either a two or three letter office designation can be arranged to direct calls to a distant office by means of a one digit, two-digit, three-digit, or four-digit code. By adding another set of wipers and a bank to the office register provision can be made for a six-digit code.

(B) The story of the director typifies the ingenuity which Strowger designers have always displayed in accomplishing a desired result by "thinking through" just one more step beyond that which had been accomplished in the past.

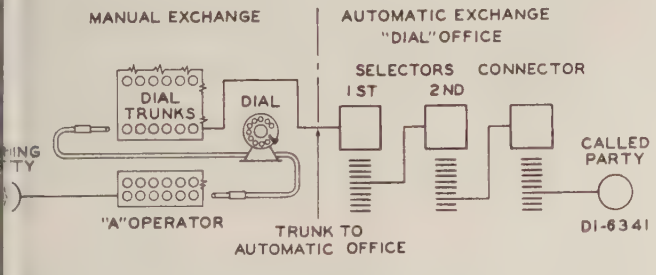
ny years before the London job was thought of, a ) office manual network was being converted to owger Automatic, and calls from the remaining nual office had to be received and sent in by opera- ss. It was then that a call storing device was de- oped to facilitate and co-ordinate the work between two offices. A set of push buttons was installed side the operator and by pushing the proper buttons ch button just once) the number to be called was gistered in an electrically operated mechanism, ich immediately on the dialing principle, begin ding the call forward.

ars later, the authorities in charge of the London twork wanted Strowger equipment installed, pro- ed it could be adapted to a wide variety of tandem nking conditions and could also be arranged to et the requirements of a universal numbering tem for the entire area.

lson, within two weeks, met the London require- nts by modifying the call storing device to send t digits differing in number and combination from sse fed into it, and making it operate from the call- dials in the subscribers' telephones instead of n push buttons in the exchange.

(c) Interconnection Between Automatic and Man-: Interconnection between automatic and manual phones is easily accomplished in several ways. nerally speaking, it may be said that an operator laced between the two systems so that she may into the automatic exchange for the manual sub- ibers and plug up connections to the manual ex- nge for the automatic subscribers. In areas of hly concentrated service the above duties are di- ed between two groups of operators, one handling calls automatic to manual and the other all calls m manual to automatic.

(d) Manual to Automatic: There are two ways of dling calls from manual subscribers. In the first thod (Fig. 2), the regular "A" manual operator's




2 - Dial "A" Board. Operator dials into automatic exchange for the manual subscriber.

ition is equipped with a dial. When a call lamp m a manual subscriber lights, the "A" operator gs into the calling jack with her "answer" cord. certaining that the subscriber wants a number in automatic exchange, she plugs the "calling" end he cord into a free trunk to the automatic office d operates her "dial" key. She then dials the nted number into the automatic exhange.

A second method (Fig. 3) is used where operators are stationed at the automatic exchanges. This is usually

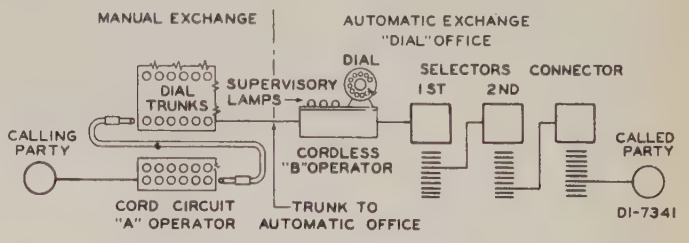



Fig. 3 - Cordless "B" Board. Operator sets up automatic connection for manual subscriber.

the case where the exchanges are part of a city system. The "A" operator at the manual exchange upon receiving a request for a number in the automatic office plugs the "calling" cord into a free jack to the automatic office. A "zip zip" tone is returned to her when a "B" operator is seized, and the manual "A" operator then passes the wanted number to the "B" operator at the automatic office. This latter operator has a cordless board equipped with either dial or a push key sender. She receives all her instructions from "A" operators in manual exchanges and without replying, sets up the automatic connections. The original "A" operator receives answer supervision when the called party answers. The trunk to the automatic office and the equipment therein are released when the "A" operator withdraws the calling plug from the jack.

213 (e) Automatic to Manual: There are three methods of handling calls from automatic exchanges to manual exchanges. The first method (Fig. 4) uses

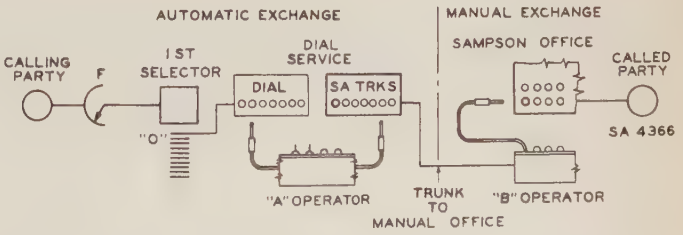



Fig. 4 - Dial Service "A" Position. Operator, in automatic exchange, passes wanted number to manual operator.

Dial Service "A" operators in the automatic exchange. These are usually reached by dialing "0." The dial service "A" operators pass the calls to "B" operators in manual exchanges who plug up the connections. Normally, the D.S. "A" operators handle short haul toll calls as well.

The second general method (Fig. 1) requires call indicator positions, each with an operator. The call indicator boards are located in the manual office. Subscribers dial the listed number, just as if they were calling a number in an automatic exchange. Thus, the call indicator makes for uniform service.

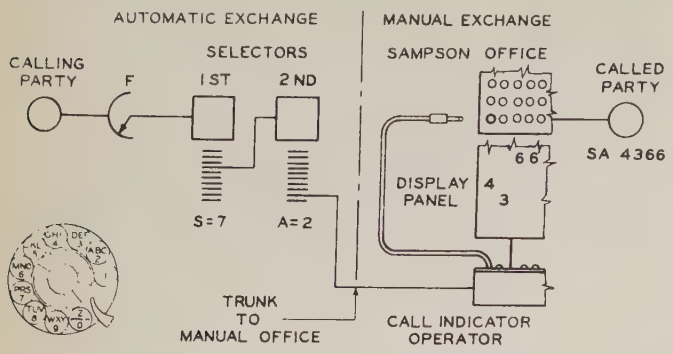



Fig. 1 - Call Indicator Position. Calling party dials wanted number, which appears on a call indicator "display panel" before manual operator, who plugs up the connection.

The operator sitting before a call indicator sees the call number appear on a display panel before her. She picks up the trunk plug designated to her by a glowing of the associated trunk assignment lamp. The operator has a complete multiple of all subscribers in the manual exchange before her and may, therefore, plug up the connection after testing for a possible busy line condition.

When the connection has been established, the display panel is darkened as is the trunk assignment lamp. When the conversation on a connection has terminated and the calling party has replaced his handset, the call indicator operator is advised of this fact by the glowing of the disconnect lamp associated with the plug ended trunk circuit. The call indicator operator need not talk to the calling party at any time.

The third method requires the use of an automatic switch train in the manual office comprehensive enough to handle all traffic which is dialed into that office. The connector bank germinals in the manual office are multipled to the manual switchboard jacks so that calls can be completed through either the manual multiple or the connector banks. Calls originating and terminating in the manual office are, of course, handled manually, but calls from an automatic exchange, or from a dial position anywhere in the network, are dialed over the central office trunks right through the switch train in the manual office, and the manual switchboard is not affected except to the extent that, whenever a local line is in use, a busy condition must be placed both on its connector terminal and on its manual board jack. While this plan is costly initially, it has the advantage of permitting a gradual shifting of lines from manual to dial, and very little equipment is installed which is not eventually used.

213 (f) Universal Numbering And Digit Absorptio

In some networks a universal numbering scheme i desired so that subscribers in all exchanges di directory numbers to reach any subscriber whethe in the calling party's exchange or in some other. Un versal schemes are sometimes objectionable fo they may require the user to dial more digits on local call than are necessary for local service alone For example, the first digit in a five-exchange net work would be used only to select the exchange t which a call is to be routed. However, the disad vantage of having an extra digit to dial in every cas is offset by the fact that the same number is alway dialed from every exchange to reach a given station

When there are only two exchanges involved, it woul ordinarily be wasteful of facilities to devote a selector rank to the selection of exchanges unless a number of the selector levels can be used for specia services. Such a selector rank may be replaced by digit absorbing springs on what were the second selectors, where sufficient vacant selector levels are available on the second selectors to care for trunks to connecting exchanges and for special services

The second selectors would then serve as both first and second selectors but would be called first selectors.

A digit-absorbing selector operates like any selector except when a digit to be absorbed is dialed. The selector raises its shaft to the dialed level, but at that point a normal post spring assembly causes the selector to release. Subsequent digits dialed, including a repetition of the one just absorbed, will cause the selector to operate in the standard manner.

Fig. 2 shows two exchanges, 4 and 5, of say 400 lines each. Exchange 5 may dial into Exchange 4 by pre-

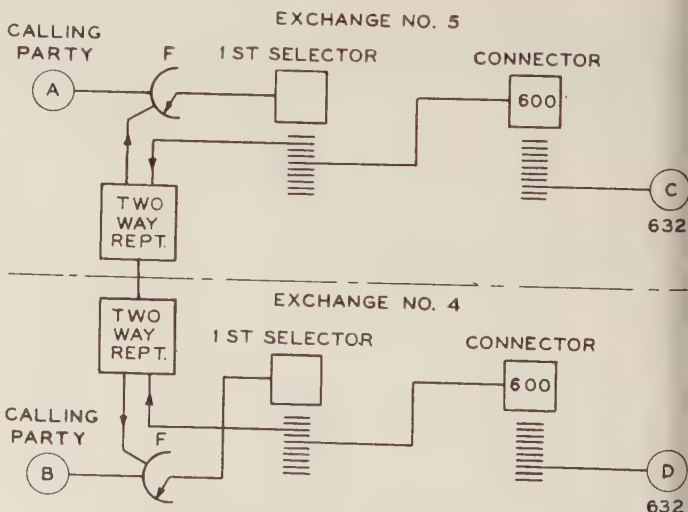
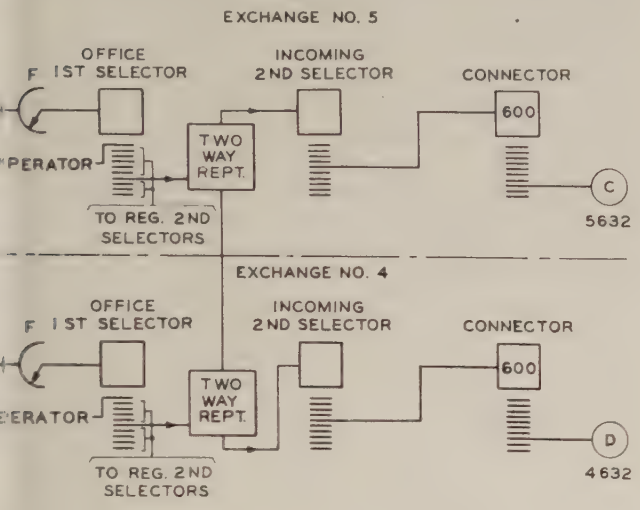



Fig. 2 - A Simple Network of Two Exchanges. "A," when dialing "B," must prefix a "9" to "B's" regular number. "B," when dialing "A," prefixes an "8."

fixing the digit "9" to the regular directory number. Subscribers in Exchange 4 must prefix an "8" to the directory number of called parties in 5. This means that one additional digit must be dialed for inter-

e calls. If a large number of such calls are e, it would be desirable to have a uniform num- ng system.

method of obtaining a uniform numbering system hown in Fig. 3. An additional rank of selectors




3 - The Network of Figure 2 Now Arranged for Universal Numbering By The Addition of Second Selectors. The first digit of the regular directory number selects the exchange. Four digits must now be dialed on all calls.

dded. The new rank, now called the first selec- , are for the purpose of selecting the called of- . The second selectors continue to select the ted connector rank. Where only two offices are lved, office selectors (first) are usually super- us unless several levels are needed for special vices.

igit-absorbing selectors are used in place of the nd selectors, as in Fig. 4, the first selector may liminated, and the uniform numbering of Fig. 3 ntained. Notice that subscribers C and D have the e numbers in Fig. 3 as in Fig. 4. When sub - ber B in Fig. 4 dials subscriber D, both of whom in the same exchange, the local first selector it-absorbing) steps to the fourth level. The digit - orbing shaft springs are operated to release the ch since the call is identified as being for the l office (4). When the next digit, "6," is dialed, local first selector will again step up and select e connector in the 600 group. Digits 3 and 2 of the ed number will step the connector to the calling

ld subscriber B in Exchange 4 dial "5632" to h C in Exchange 5, the local first selector at nange 4 will step to the fifth level and cut in on a trunk to Exchange 5. Thus, the digit-absorbing ngs are not operated when the call is destined for her office. The remaining three digits operate regular switch train in the 5 office. Digit "6" cause the incoming selector to step to the 6th el and select a free connector in the 600 group ts "32" will step the connector to the wanted y's line.

Note that since a local 1st selector with the digit absorbing feature combines both the functions of an office selector and those of the next regular selector rank, the 1st selector (digit absorbing) will combine the levels of the two switches. Since the total number of levels cannot exceed 10, it is obvious that there is a limit to the application when the number of subscribers is such that close to 9 levels are needed for connections to local trunks or services (e.g., next switch ranks) as one level in the selector is required for each outside office.

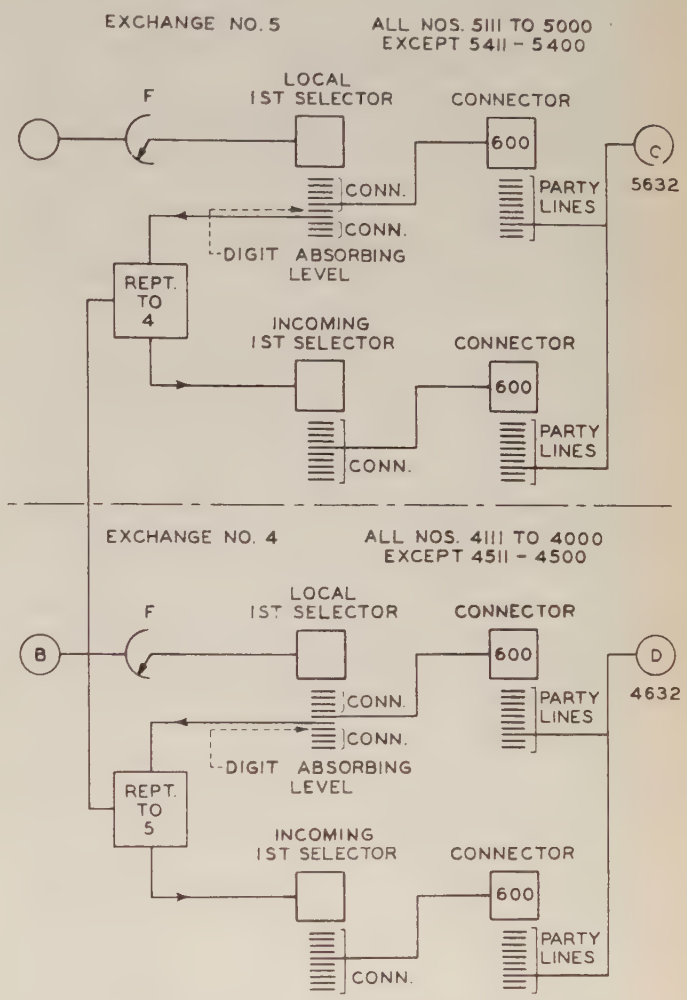



Fig. 4 - The Network of Figure 2 Now Arranged for Universal Numbering by the Use of Digit Absorbing First Selectors. Four digits must be dialed on all calls.

213 (g) For further discussion of trunking from Manual to Automatic, see AT (Baer) 7-19; for automatic interoffice trunking, see AT (Soler) 5-19. AT (Clark) 8-19 and AT (Campbell) 1-20.

214 Switch Trains: The nomenclature used in this and following sections should not be considered as being either authoritative or preferred. As each particular circuit is discussed, care has been exercised to use the exact terms appearing in the title box of the circuit in question and in the accompanying circuit explanation.

215 The Local Switch Train: The various switch trains differ primarily in the connector used as the last switch in the switch train established between a calling and called subscriber.

215 (a) Regular Straight Line Connector: This type of connector forms part of the local switch train terminating in the regular connector groups. It is utilized to complete incoming calls to subscribers' station terminals as the result of the impulses representing the last two digits of the desired station number.

The designation "Regular" (Local) distinguishes this type of connector from other more complicated switches having various special features; the designation "Straight Line" (Individual) distinguishes this type from connectors serving party lines and from connectors of the trunk-hunting type.

Various features of the "Straight Line" connector have already been discussed in Sections 205 (a)to 205(g), inclusive.

215 (b) Local Trunk Hunting Connectors, With Night Service Feature: This type of connector forms part of the local switch train terminating in the trunk-hunting connector groups. It differs from the regular local connector described in Sec. 215 (a) in that it not only responds to the last two digits of the dialed station number but thereafter is capable of automatically hunting for and seizing the first idle terminal in the selected trunk group, when all trunks are connected to consecutive terminals on the same level. It is thus enabled to test a group of P.B.X. trunks, or a group of consecutively numbered lines, and to establish connection with an idle trunk or line; or to return busy tone only in case the entire group of terminals is busy.

Connectors providing this service have been variously termed "Trunk-Hunting," "P.B.X.," "Rotary" or "Group" connectors. The service is sometimes referred to as "consecutive number" service, while the Navy terms it "Hunt-the-Not-Busy-Line" service.

The connector under discussion is seized over the customary three conductor trunk (+L, -L and C); and is equipped with four wipers (+, -, C and EC). The C and EC (extra control) wipers have access to a 200-contact private bank. The lower bank contacts served by the "C" wiper are the customary "private normals"; the upper contacts served by the "EC" wiper are used for marking the trunk groups, and are multipled thruout the group of connectors, and thence to a terminal block for convenient strapping between the "C" and "EC" terminals.

For a complete discussion of a specific trunk-hunting connector, see A.E.Co. Bul. 813, Sec. 2.

(A) Number Assignment: A desired group of trunks, to be served by the connector under discussion, may be established as follows: (1) ground the upper private (EC) bank contact of the first trunk in the grou and (2) connect a suitable resistance between the u per (EC) and lower (C) private bank contact of t last trunk in the group.

It will be noted that no connections need be made fo individual line service, nor for intermediate trunk in the group.

For complete discussion of number assignments trunk-hunting groups, see A.E.Co. Bul. 512, Sec. and Bul. 654, Sec. 12.

(B) Trunk-Hunting Function: When an individual line is called, the connector under discussion wi function as a "Regular Connector" and return bus tone if the called line is engaged. However, when t directory number of a trunk group (which is that the first trunk in the group, sometimes called t "pilot number") is called, the "EC" wiper will fi direct ground on the contact upon which it comes rest, thereby bringing into operation the automat selecting feature. If the first trunk in the group i idle the connector will stop thereon and ring; but the first trunk is busy the switch will advance auto matically in search of the first idle trunk. In t event that all of the trunks are busy; the "EC" wi er, upon reaching the last trunk in the group, will fi ground through a resistance. The connector will the stop, and busy tone will be returned to the callin party.

(C) Another Method of Establishing Groups: In an other trunk-hunting connector, the grouping is e tablished by strapping together the upper and lowe private bank contacts of the last trunk in the group The service rendered is the same as that describe above, but a peculiar requirement exists in connec tion with "night service." See below.

In still another trunk-hunting connector, the groupin is established by tying together the upper and lowe private bank contacts of each trunk in the group, e cept the last. This method of P.B.X. trunk selectio is still the most widely, see Sec. 404 (d).

The service rendered is the same as that describe in the preceding paragraphs, but here also a pecu liar requirement exists in connection with "nig service." See below.

(D) Night Service for P.B.X. Trunk Groups: When P.B.X. operator leaves the switchboard at the end the business day, certain extension telephones a connected to the trunks to the central office. Thes connections clear the trunks of all attachments, a leave the extensions connected directly to the ce tral office to make or receive calls without the a of the P.B.X. operator.

(E) Connectors Having Night Service Feature: Whe connectors of the type discussed are employed, a trunks, with the exception of the first trunk in t group, can be assigned for night service. When night service number is dialed, this connector wi

on the number called, even though that trunk is , because the automatic rotary feature is opera- only after a "pilot number" has been called.

Connectors Without Night Service Feature: When ectors of this type are employed, it is necessary ssign night numbers, other than those assigned to runk group for day service. If this were not done a person called the number of an intermediate which happened to be busy, the connector would e to the first idle trunk in the group, thus the g night station would be signaled. This is be- e the automatic rotary feature is always opera- in a connector of this kind. As an exception to bove, it may be noted that the last trunk in the p can be assigned for night service.

Groups of More Than Ten Trunks, But Not to eed Twenty: When the ultimate trunk group is e than ten, but less than twenty, service thereto still be rendered by the trunk-hunting connector ribed in Sec. 215 (b). When it is desired to serve e than a ten-trunk group, the connector banks be multipled in two groups, instead of being all ae multiple.

uming there are twenty connectors on the board, anks of connectors 1 to 10 may be multipled, to m the first group. The banks of connectors 11 to ay be multipled to form the second group. For level of ten numbers, there will now be a total wenty trunks, and calls from certain connectors go out over one set of ten trunks while calls over r connectors will go out on the other set of trunks.

scheme has wide application, but it should be embered that some calls may receive the "all- nks-busy" signal even though there are idle ks in the other group.

Disconnect Supervision to Called Manual Ex- ge: When "calling party release" connectors Sec. 205-q) are used, and disconnect super- on is required on calls to a manual exchange, it ustomary to reverse the "+" and "-" normals e banks served by the trunk-hunting connectors. s the polarity of the line will be reversed when alling party releases the switch train, and dis- ect supervision will be given the manual ex- ge.

(c) Local Level-Hunting Connector, With Night ice Feature: This type of connector forms part e local, switch train terminating in the level- ing connector groups. It differs from the trunk- ing connector described in Sec. 215 (b) in that it ides facilities for serving groups of more than terminals each and up to 100 terminals, whereas trunk-hunting connector is limited to serving not e than ten terminals, except as stated under Sec. (b) (G).

nectors providing this feature have been termed vel-Hunting Connectors" or merely "Selectors." ot confuse with the switch called a "Selector- nector," see Sec. 175 (b).

The connector under discussion is seized over the customary three conductor trunk (+L, -L, and C); and is equipped with five wipers (+, -, C, EC and a vertical wiper which engages a vertical bank. The trunk groups served by this connector are formed as outlined in Sec. 215 (b) (A).

The local level-hunting connector responds to the last two digits of the number dialed, and thereafter it automatically hunts for and seizes the first idle terminal in the selected group, which group may consist of more than ten terminals located on adjacent bank levels. The directory listing will be only that of the first terminal in the group, (the pilot number).

The first automatic rotary movement of the connector switch wipers is from the pilot terminal (assuming that the pilot terminal tests busy) across the remaining terminals of the bank level until the first idle terminal is reached; or, if all the remaining terminals on the level are found busy, until the eleventh rotary position is reached. From this point, the connector switch wipers will be automatically released across the bank level; raised one step to the next higher bank level, and will automatically be rotated across this bank level until the first idle terminal of the group is selected, or the eleventh rotary position is reached. This automatic level hunting, and terminal hunting, is continued until an idle terminal of the group, is found; or until the last terminal of the group is found busy, whereupon the connector will return busy tone to the calling station.

A level-hunting group may range in size from 11 to 100 trunks or lines. It is necessary that the trunks or lines of such a group be consecutively numbered and connected to terminals in adjacent bank levels. The local level-hunting connector will hunt consecutively from a pilot terminal in any level to any higher bank level, by hunting through the higher levels in consecutive order from the level in which the pilot terminal was located.

This connector will also serve individual lines or groups of ten or less trunks. Thus a level hunting board may be "proved in" where only one small level-hunting group is required.

(A) Number Assignment: For number assignment within level hunting groups, see A.E.Co. Bul. 512, Sec. 2, and Bul. 654, Sec. 13.

215 (d) Bank Arcs: Bank arcs were originally developed to afford additional bank contacts on trunk hunting connectors, and were called "P.B.X. Bank Arcs." The English version is thus described in A.E.Co. Bul. 356: "The P.B.X. bank arc occupies a position in front of the switch banks and is hinged so that it can be swung out to the right. This bank arc consists of a stamped plate per level. Each contact plate can very readily be withdrawn and replaced, while the individual contacts may readily be clipped off as is required for the last line in each P.B.X. group. This design permits the mounting of two separately insulated contact plates per level,

thus rendering a 200 contact arc available where required.

Bank arcs have other uses, and are discussed as follows in A.E.Co. Bul. 368 covering the use of Sigo's "Multiple Pen Recorder". "Bank arcs are essential when it is desired to obtain records of "lost calls," using a Combination Relay Unit in conjunction with a Multiple Pen Recorder. There are two types of bank arcs, namely, the single-contact type and the eleven-contact type. Both are single-level but are adjustable so that they may be used on any level, and readily changed to any other level when desired. The single-contact bank arc is used on connector switches for individual line observation, while the eleven-contact bank arc is used on selector switches for selector level observations.

"The bank arcs are designed to clamp on the left bank rod of the connector, or selector, switch banks.

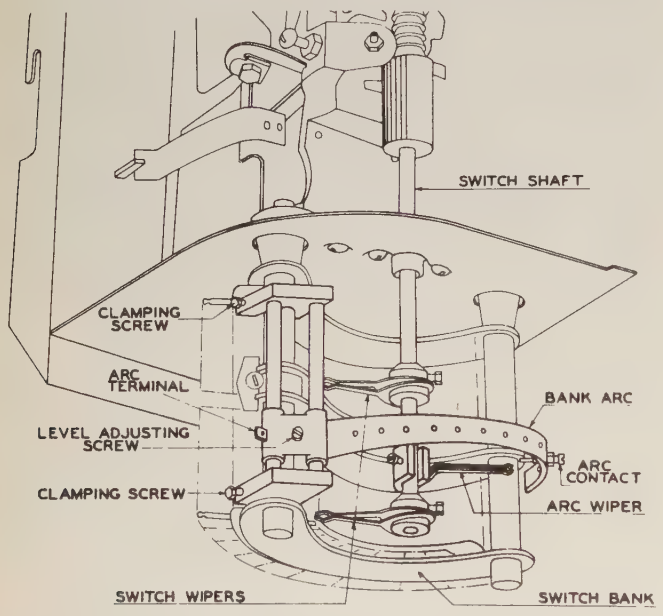



Fig. 1 - P.B.X. Bank Arcs.

Fig. 1 shows a bank arc of the single-contact type mounted in place on a connector switch bank rod. Note that the arc curves around in a semi-circle opposite the regular switch banks. The arc is equipped with eleven tapped holes corresponding to eleven rotary steps of the switch, but with only one arc contact. This contact is in the form of a screw and it is readily inserted into any one of the eleven tapped holes. It is set diametrically opposite the horizontal bank position of the line which is to be observed. In the case of the eleven-contact bank arc used for selector level observation, an arc contact is set into each of the eleven tapped holes. An arc wiper is clamped on the switch shaft just above the lower switch wiper, and pointing in the opposite direction. The arc wiper is adjusted to engage the arc contact, or contacts, when the switch cuts in on the level to which the bank arc is set. The regular switch wipers are not disturbed. To take an example, let us assume a switch steps vertically to the level to which an eleven-contact bank arc is set. As the switc makes the first rotary step the regular switch wiper engage the first bank contact, and at the same tim the arc wiper engages the first arc contact. As th regular switch wipers engage successively bank con tacts number 2, 3, 4, etc., the arc wiper engages ar contacts number 2, 3, 4, etc., correspondingly. Fig. 1 the arc contact is shown screwed into the sec ond tapped hole and would thus be engaged on th second rotary step."

216 The Toll Switch Train: The language of autc matic telephont has many dialects. Particularly i this true of any discussion relating to toll switc trains. In these sections there has been no attem at consistency. The nomenclature used on the partic ular circuit and circuit explanation under discussic has been used. Sometimes a supervisory lam "glows"; sometimes it "lights." Sometimes the sul scriber "dials" a number; sometimes he "calls" number. However, in spite of the inconsistencie we doubt whether the student engineer will find a unfamiliar telephone term. It is to be hoped th progress towards standardization of nomenclatu will eventually get under way, but that is not to b expected in the writer's lifetime.

216 (a) Toll Transmission Selector: The toll trans mission selector functions in the same manner as local selector when hunting a trunk leading to a to intermediate selector or toll connector. It diffe from a local selector in that after the searching op eration is completed, it has additional duties; namel to repeat the impulses to the toll connector, to supp talking current to the called subscriber, and to pro vide for all necessary supervision.

This switch forms part of the toll switch train a extends calls to all types of toll connectors, whethe they are Toll connectors proper, Combination To and Local connectors, Combination Local and To Trunk-Hunting connectors, or Toll Level-Huntir connectors.

Switches performing this service have been un formly designated "Toll Transmission Selectors.

The switch under discussion is seized over a three conductor trunk (-Line or "R", +Line or "T", an C or "S"), and is equipped with four wipers (+, -, and EC). The fourth wire, termed the "extra contro lead, is necessary to control the start of ringing the combination connector.

Connector functions peculiar to toll operation will discussed under appropriate sections below.

216 (b) Toll Connector: This type of connecto where used, forms part of the toll switch train te minating in the regular connector groups. It diffe from the regular connector described in Sec. 205 ( in that it is utilized to handle incoming traffic fro the toll switchboard.

nectors performing this service have been uni-
ıly designated "Toll Connectors."

connector under discussion is seized over a four-
duct or trunk (+Line, -Line, C and EC); and is
pped with three wipers +, -, and C).

toll connector, once used to serve the regular
ector groups, has been largely supplanted in later
tice by the "Combination Local and Toll Connec-
; therefore, no detailed discussion of its functions
be given here.

(c) Combination Local and Toll Regular Con-
or: This type of connector is the last switch in
the local switch train and the toll switch train,
serves the regular connector groups. It differs
the local regular connector described in Sec.
(a) in two essential points. First, it is acces-
from the local switch train and also from the
switch train, and therefore is utilized to handle
ming traffic from the toll switchboard as well as
the local stations. Second, the circuit arrange-
t is such that, when the switch is seized from the
switch train, it functions as a regular local
ector, and, when seized from the toll switch
, it functions as a toll connector.

s from the local switch train test all of the regu-
ocal connectors in the group before selecting a
ination local and toll regular connector; calls
m the toll switchboard test only the combination
and toll regular connectors, and in reverse
r of selection to that of the local switch train.

hes performing this service have uniformly been
nated "Combination Local and Toll Regular
ectors."

a method of analyzing the traffic carried by com-
ion local and toll connectors, see A.E.Co. Bul.
Sec. 36.4.

connector under discussion is seized, from the
eding local switch, over a three-conductor trunk
ne, -Line and C); or, from the preceding toll
h train, over a four-conductor trunk (+Line, Toll
d EC). It is equipped with three wipers (+, -,
C).

e following sub-sections, only those functions will
iscussed which are peculiar to toll operation.

Seizure Supervision: To complete a call from
oll board to an automatic subscriber, the opera-
nserts the calling cord into a trunk jack leading
toll transmission selector in the automatic of-
operates the "dial" and "talk" keys, and dials
esired number.

last two digits of the number dialed cause the
ation of a combination toll and regular connector.
ne event that the called line is idle, the wiper-
ng relay functions to remove battery feed to the
eding switches, thus producing a "dry trunk."
whereupon the toll transmission selector reverses battery back to the toll board. This reversal of current causes the calling supervisory lamp to light which gives the operator "seizure supervision." The wiper-closing relay also functions to lock up the ring-cut-off relay, so that the called party will not be rung immediately.

(B) Flash Busy: If the called line is engaged, the busy relay functions to replace the battery feed to the preceding switches with a periodic (60 or 120 IPM) ground. The toll transmission selector then extends seizure supervision and periodically reverses battery back to the toll board. This periodic reversal of battery causes the calling supervisory lamp on the toll board to flash as an indication that the called line is busy.

When a busy condition is encountered, the toll operator must release the connection and dial the number again in the same manner as a subscriber.

(C) Toll Offering Service: It is possible for the operator to reach a busy line through the verification switch train (see Sec. 217 (a) (H) for this form of "toll offering" by way of a toll connector).

(D) Camp-On-Busy: Connectors having this feature provide means whereby the toll operator may "offer" if the called line is busy, i.e., the toll operator is cut in on the busy line and she may ask the called party if he wishes to interrupt his conversation and receive the incoming toll call. If she decides to camp-on-busy, instead of offer, she will receive a signal when the called line becomes idle, and may start the automatic ring at her pleasure.

Certain connectors give the called party a "warning signal" at the time of the camp-on-busy function, the ringing being automatic when the called party hangs up. There is no offering feature here.

(E) Toll Breakdown (Disconnect): A combination toll and local connector which provides toll offering may also permit "toll breakdown." Here the toll operator may actually break down a local connection which is making the called line busy.

(F) Delayed Ring: The toll operator can start the ringing, as soon as she is ready, by momentarily throwing her "Ring" key. This operation connects alternating current to the toll trunk, operating an A.C. relay in the toll transmission selector which removes generator ground from the E.C. lead, thus permitting the ring-cut-off relay of the connector to restore to normal and start the automatic ringing of the called party. The connector furnishes a ring-back tone to the toll operator.

For an application of delayed ring in toll practice, see A.E.Bul. 361, Sec. 22.

(G) Re-Ringing: Should the called party restore his receiver, the toll operator can re-start the automatic ringing of the called line by again momentarily operating the "Ring" key.

(H) Answering Supervision: When the called party answers, the ring-cut-off relay again operates and the toll transmission selector feeds battery to the called line. This results in the extinguishing of the calling supervisory lamp on the toll switchboard.

216 (d) Combination Local and Toll Trunk-Hunting Connector: This type of connector forms part of the local switch train and the toll switch train terminating in the trunk-hunting connector groups. It differs from the local trunk-hunting connector described in Sec. 215 (b) in two essential points. First, it is accessible from the local switch train and also from the toll switchboard, and therefore this connector is utilized to handle traffic from the toll switchboard as well as from the local switch train. Second, the circuit arrangement is such that, when the switch is seized from the local switch train, it functions as a local trunk-hunting connector, and, when seized from the toll switchboard, it functions as a toll trunk-hunting connector.

As in the case of Combination Local and Toll Regular connectors, calls via the local switch train test all of the Local Trunk-Hunting Connectors before selecting a Combination Local and Toll Trunk-Hunting Connector. Calls from the toll switchboard test only the Combination Local and Toll Trunk-Hunting Connectors, and in reverse order of selection to that of the local switch train.

The switches performing this service have uniformly been designated "Combination Local and Toll Trunk-Hunting Connectors.

The connector under discussion is seized, from the preceding local switch train, over a three-conductor circuit (-Line, +Line and C); or from the preceding toll switch train over a four-conductor circuit (-Line, +Line, Toll C and EC). It is equipped with four wipers (+, -, C and EC).

The functions described in Sec. 216 (c) for the combination local and toll regular connectors apply also to the combinations local and trunk-hunting connectors.

216 (e) Toll Level-Hunting Connector: This type of connector forms part of the toll switch train terminating in the level-hunting connector groups. It differs from the local level-hunting connector described in Sec. 215 (c) in that its circuit is such as to cause the connector to function as a toll connector.

The switches performing this service have been uniformly called Toll Level-Hunting Connectors.

The connector under discussion is seized over a four-conductor trunk (+Line, -Line, Toll C and EC), and is equipped with four wipers (+, -, C and EC).

The toll functions described in Sec. 216 (d) for the combination local and toll trunk-hunting connector also apply to the toll level-hunting connectors.

216 (f) Combination Local and Toll Level-Hunting Connectors: Owing to space requirements, no combination local and toll level-hunting connectors have been developed.

216 (g) For a complete discussion of a specific toll switch train, see A.E.Co. Bul. 816.

217 The Test Switch Train: There are usually two test switch trains provided in a large automatic office; (1) the test train proper from the test desk, and (2) a verification train from the toll switchboard. The first switch in each train is usually a "Test Distributor" (although sometimes a "Test Distributor Selector"). The two test distributors have common access to a single "Test Connector" which appears in each of the connector groups. There is only one type of test connector, the one type forming a part of the test and verification trains terminating in the regular connector groups, the trunk-hunting connector groups and the level-hunting connector groups.

217 (a) Test Distributor: The test switch train is made up of two or three types of switches depending on whether the exchange is a single office or multi-office system, and in the latter system, upon the number of offices. In a single office exchange, and in some of the multi-office exchanges, the test train switches used are a test distributor and a test connector. In other multi-office exchanges a test-distributor selector is required in addition to the aforementioned two types of switches.

The test distributor selector is a switch similar in appearance to an ordinary selector, except that both of its banks are 200-contact. Like the selector, it has a dial-controlled vertical motion and an automatic rotary motion.

The test distributor and the test connector are both similar in appearance to an ordinary connector and, like the connector, they have dial-controlled vertical and rotary motions. The test distributor, however, has three 200-contact banks.

The test distributor selectors are located in the same office as the centralized test desk, and are connected to it by means of four-conductor trunks. The test distributors are connected to the test distributor selectors by four-wire inter-office trunks, and the test connectors, one for each hundred-line group, are connected to the banks of the test distributors in the same office by means of six-conductor trunks.
The purpose of the test-distributor selector is to select an idle test distributor in any one of the offices of the exchange network; that of the test distributor, to select the test connector associated with any one of the hundred-line groups in the office; and that of the test connector, to select the line to be tested in a particular one-hundred line group.

ti-office exchanges having only a few offices em-
y direct trunks from the test desk to the test
ributors in each office, thus rendering unneces-
y the test-distributor selector. As the latter
tem is simpler, while still containing all of the
ments of the testing scheme, the latter circuit
be the one explained herein.

tches performing the service to be discussed in
section have uniformly been designated "Test
tributors."

test distributor under discussion, as used in
er the verification or the test train is seized over
ve-conductor trunk (+Line, -Line, EC, +Test and
st). It is equipped with six wipers (+Oper, -Oper,
nd EC, +Test and -Test).

ne following subsections, only those functions will
liscussed which are peculiar to test distributor
ration.

Test for Busy Test Connector: If the desired
connector is in use, wiper "C" of the test distri-
or will find ground on the "C" lead to the test
nector in question; whereupon the busy relay of
test distributor will function (1) to place busy tone
he calling line, and (2) will reverse the polarity
ne calling line to also give a visual busy signal.

is, the tester receives both a busy tone and a
al signal when the dialed test connector is in use.
tester is not forced to release but may hold the
k until the connector becomes idle.

Test Connector Becomes Idle: When the test
nector becomes free, removal of ground from the
connector "C" lead will cause the busy tone to
emoved and the polarity of the calling line to be
urned to normal, thus extinguishing the super-
ry lamp.

removal of the busy tone and the visual signal in-
the tester that the dialed test connector is now
ilable. This is an illustration of "Camp-on-
."

Impulsing the Test Connector: When the last two
s are dialed, the test distributor repeats those
ulses to the test connector over the operating
s, and disconnects the testing pair from its test
rs, so that the test connector may not interfere
the lines over which its wipers pass.

Test for Busy Line: If the called line is in use,
r "C1" of the test connector will find ground, re-
ing same over the "C1" lead to the "EC" wiper
e test distributor, whereupon the polarity of the
ling line is reversed to give the tester a visual
signal.

Called Line Becomes Idle: When the called line
omes idle, the polarity of the calling line is re-
ed to normal thus extinguishing the busy signal:
3.C.O. relay is operated to clear the called line
of attachments and the test pair is extended to the called line. This is another illustration of "Camp-on Busy."

(F) Further Rotation of Test Connector: It is to be noted that the circuit to the rotary magnets of the connector is not opened following the dialing of the last digit in the call number.

So, the tester may further advance the wipers of the test connector should he desire to make tests on consecutive lines on the same level.

(G) Release of Test Connector Only, or Release of Entire Switch Train: The tester may release only the test connector by operating the "Connector Release" key, or he may release the entire switch train by restoring the "Hold" key to its normal position.

(H) Verification Service: Aside from the use of the test switch train for testing purposes, it can also be utilized by certain operators for, (1) verification and, (2) toll offering services. In these cases, a separate group of test distributors or test-distributors selectors, having access to the same test connectors used by the tester, are usually furnished for the operators' exclusive use.

These test distributors or selectors are generally termed "verification switches." By means of this "verification switch train" it is possible for an operator at a position on which the verification trunks terminate, to dial a busy telephone number and, (1) listen in on the line to verify whether it is actually in use, or (2) to inform one of the talking parties that a toll call is being held, awaiting the termination of the conversation. The toll call, however, is completed over the regular channel provided for the purpose and not over the verification switch train. The verification switch train also permits the operator to verify the calling station's number on request for toll calls. See A.E.Co. Bul. 361.

For "toll offering" by way of a toll connector see Sec. 216 (c) (D).

(I) Verification Circuit: When used for verification service, the test distributor has the line and test wires connected together by 2-M.F. condensers. These condensers furnish the path by means of which the verification operator's telephone is connected to the test lines and thence to the dialed line.

217 (b) The Test Connector: This type of connector forms part of the test and verification trains terminating in the regular connector groups, the trunk-hunting connector groups and the level-hunting connector groups.

The test connectors are accessible from the banks of test distributors switches to provide: (1) Verification train to automatic stations from the toll switchboard; and (2) test train to automatic stations from the test desk.

The switches performing this service have uniformly been designated "Test Connectors."

The test connector under discussion is seized over a six-conductor circuit (+Line, -Line, RT (C1), RT-1 (C), +Test and -Test); and is equipped with three wipers (+. - and RT (C1).

The circuit arrangement of the test connector is such that the connector advances its wipers to the dialed station terminal, guards the selected terminal from intrusion, and extends a test circuit through to the selected terminal, even though the selected terminal tests busy. The circuit arrangement further provides for the advancing of the test connector wipers terminal by terminal across any bank level, in response to successive dialing of the digit one.

The test connector is not arranged to function as a trunk-hunting connector in the trunk-hunting connector groups; nor as a level-hunting connector in the level-hunting groups.

When the pilot number of a trunk-hunting or level-hunting group is dialed, the test connector will stop on the pilot terminal, regardless of a busy condition. To step the test connector to the next terminal of the group, digit one is dialed. Successive dialing of the digit one will cause the test connector to advance step by step across the terminals of the same bank level. To step the test connector to the terminals of the next higher bank level, the test connector must be first released to the normal position and then dialed to the first terminal of the next higher bank level.

217 (c) Combination Local and Test Connector: Combination local and test connectors are very unusual, but they have been used.

217 (d) For a complete discussion of a specific test switch train, see A.E.Co. Bul. 815.

218 Party Line Service:

218 (a) Terminal Per Station Service: The terminal per station scheme makes for the most simple connector and will be considered first.

(A) Two-Party, Divided Ringing, Selection Made in Connector Bank, M.A.X.: The connector discussed in Sec. 205(a) may be utilized to provide this particular combination of services.

A two-party line is established by connecting the ringer of one station (a) between the "+" side of the line and ground; and the ringer of the second station (b), between the "-" side of the line and ground. Any two connector terminals may be assigned to the two-party line, assuming that there is a L.I.D.F. in the office. One connector terminal (c) is connected "straight" to the two-party line, while the second connector terminal (d) is connected "reversed" to the same line, i.e., the + and - line leads are reversed.

Remembering that the connector under discussion applies battery connected generator to the "-" line wiper, it follows that station (b) will be signaled when the (c) terminal is reached, and that the (a) station will be signaled when the (d) terminal is reached.

To connect the first connector terminal, jumpers are run from one of the connector terminals (vertical side of L.I.D.F.) to a terminal strip on the horizontal side which is cabled to the main distributing frame and there cross-connected to the two-party line. The cabling from the line relay circuit is also terminated on the horizontal side of the L.I.D.F., in multiple with the line cabling from the main distributing frame.

To connect the second connector terminal, jumpers are run from the second connector terminal (vertical side of L.I.D.F.) to the same terminal strip on the horizontal side as the first connector terminal is jumpered. In this instance, however, the jumpers from the second connector terminal are not connected directly to the same terminals to which the first connector terminal is jumpered. Instead, the jumpers from the second connector terminal are connected to a separate group of terminals on the strip known as "second station" terminals. These "second station" terminals are connected by means of short reversed straps to the terminals to which the first connector terminal is jumpered.

The reversed straps between the first and second station terminals provide the facility for causing the connectors to ring the proper station of the two-party line.

For the actual method of making the cross-connections, see A.E.Co. Bul. 654, Sec. 15.

(B) Two-Party, Divided Ringing, Selection Made in Connector Bank, P.A.X.: The principle discussed above may be applied in a 50-line P.A.X., served by a 100-line connector, by reversing the line normals in the upper five levels and connecting terminal 61 with 11, 62 with 12, etc. The call number of the second party will then be displaced by 50 from that of the first party.

So, numbers 11 to 50 can be assigned to individual lines (or to the first party on a two-party line) and the connector will ring over the "+" line; the numbers assigned to the second party are all in the upper five levels, and when called, the connector will ring over the "-" side of the line.

(C) Five-Party Harmonic, Metallic Ringing, Selection Made by Preceding Switch: When the terminal per station scheme is used, one hundred five-party lines can be served by five groups of connectors, such as the connector discussed in Sec. 205 (a). The banks of all the connector groups are in multiple, and the connectors of each group are arranged to ring with one of the five harmonic frequencies. Five harmonic ringers are bridged across the party line, each being of a different frequency.

order that the desired frequency may be selected the third digit from the last in the directory num-, access to each group of harmonic ringing con-tors is obtained by way of a different level in the nks of the preceding rank of selectors.

Two-Party, Divided Ringing, Selection Made by eceding Switch: The connector under discussion s two appearances in the banks of the preceding tch. If seized from one appearance it rings over "+" line, while if seized from the other appear-e it will ring over the "-" line.

(b) Terminal Per Line Service: When the sel-ion of the party is to be made within the connector, thrid digit from the last (usually) will operate a cuit device to cause the connector to ring out over line wiper or the other, or to select the desired quency.

digit in question performs a numerical service ch is a part of the call number and is not an illu-ation of "digit-absorption," although that term has metimes been mis-used in this connection. For a eferred use of the term "digit-absorption" see . 213 (f).

Two-Party, Divided Ringing: In this particular nnector, the third digit from the last actuates a nor switch. If the digit dialed is "9", the con-tor will ring over the "-" side of the line; while ny other digit is dialed on the minor switch, the nector will ring over the "+" side of the line.

Frequency Selecting Connector: A frequency ecting connector is similar in appearance to the ular connector with the addition of a frequency ecting mechanism usually consisting of a minor itch. The circuit is so arranged that the proper ging current is selected by a digit dialed before or er the vertical and rotary operation of the con-tor shaft. By the use of a frequency selecting con-tor, any telephone on a 10-party line may be sig-ed individually if harmonic 5 frequency ringing is ed.

e minor switch has its own rotary and release agnets and is equipped with a double set of bank ntacts and wipers.

Frequency Selecting Connector; Frequency Sel-ed Last: This connector performs all the func-ns of a regular connector, and in addition selects proper ringing frequency and the correct side of line for ringing the called station.

e last digit dialed actuates a minor switch having levels of bank contacts. The upper row of con-ts on the top level are connected to five different equencies, contacts 1 to 5 connecting to frequencies o 5 and contacts 6 to 0 also connecting to fre-encies 1 to 5. The lower row of contact on the top rel is divided into two groups, all the contacts of ch group being multipled together. Only two op-ating conditions are possible, that selected depends upon whether the minor switch wipers rest on a contact from 1 to 5 or on a contact from 6 to 0.

The ten telephones are connected across the line but the ringers are connected between either side of the line and ground. Five of the ringers are connected to the - line and five to the + line making it possible to ring one bell at a time by means of one of the five frequencies.

The impulses of the frequency selecting digit rotate the minor switch wipers to the desired contact. The top wiper will then connect one of the five ringing frequencies to one of the multiple groups to select the ringing side of the line.

Assuming "5" was the digit dialed, the wipers will be resting on contact 5 which is in the first group, therefore, the connector will ring over the "-" side of the line to ground at each of the ringers connected to the "-" line." The ringer which is tuned to frequency 5 will be the only one to respond.

If the digit dialed had been from 6 to 0, inclusive, the wipers would have made contact in the second group, therefore, the connector would have rung over the "+" side of the line with frequency 5.

An alternate version of the above arrangement is one in which the - side of the line is signaled if an odd digit is dialed, and the + side of the line is signaled if an even digit is dialed.

For a complete discussion of a specific frequency selecting connector see A.E.Co. Bul. 813.

(D) Frequency Selecting Connector; Frequency Selected First; Connectors which select the frequency first, are sometimes used.

218 (c) Reverting Calls: On party lines, special provision must be made such that any subscriber may call any other party on his line. (Ordinarily, should a subscriber attempt to dial the directory number of his line, he would, of course, receive the busy tone, because he, himself, is occupying the line.) Although the percentage of party line calls is quite small, some provision must be made for handling them. Therefore, apparatus which allows a person on a party-line to signal and talk with another person on the same line, is employed. This apparatus is termed "reverting call equipment."

(A) Reverting Call by a Special Number: Most frequently, the subscriber dials a special number in place of the regular directory number. The dialing of this number connects through to a reverting call switch which is caused to operate. After dialing the number, the calling person replaces his handset on the cradle. The reverting call switch will then cause the bells of the calling telephone and of the called telephone to ring. When the called person answers, the ringing of both bells is stopped. This silence notifies the calling person that the telephone has been answered. The calling party then removes his hand-

set and starts the conversation. If the called telephone is not answered, the calling party may stop the ringing by momentarily removing his handset from the cradle.

The special number may be furnished by an information operator, by a card furnished each party line subscriber, or by information contained in the directory, depending on the system involved and the local operating company's preference.

The reverting call switch is useful to installers, testmen, and repairmen who may want to ring the telephone station on which they are working without the assistance of a central office operator or repair clerk.

For further discussion, see AT (Walker) 5-29 and A.E.Co. Bul. 518 and 814.

(B) Reverting Call by Prefix to Directory Number: In certain C.A.X's where each subscriber's call number consists of five digits, reverting calls are made by first dialing a single prefix followed by the five-digit number. Under this plan the calling party must know that both he and the called party are on the same line. Simple directory information tells him what prefix to dial.

The dialing of the prefix seizes a reverting call switch, which thenceforth, utilizes only the ringing digits of the called number. Thus, the first, third, and fourth digits (line selecting) of the individual subscriber's number are absorbed. The second digit selects the service, first or second 10 codes or side of line on which to ring; the fifth digit selects the code or frequency.

In this type, the calling party may receive no indication that the called party is being rung. The called party will, however, receive a reverting call signal when he answers which will hold him on the line, thus giving the calling party time to answer. The connection is released a few seconds after the call is answered, talking battery being supplied from the line relay. In case of an incomplete call or an unanswered call, the connection is automatically timed to release.

(C) Reverting Call by Directory Number: On certain switchboards, especially the very small, the connectors provide facilities for calling between subscribers on a party line by dialing the directory number. This connector performs all of the functions of a regular party line connector and in addition serves as a reverting call switch when a subscriber dials another subscriber on the same line.

The question that naturally arises is, "how does the connector know that it is making a reverting call?" When calling any number other than that of the calling party, there can be no circuit completed between the "C wiper" of the connector and the "C lead" of that same connector. But when a connector is advanced to the calling party's number, the "private normal" of the calling line completes a circuit from the "C" wiper to the "C" lead of the connector. Knowing that it is a reverting call, it will function in the required manner.

When a reverting call is made, the calling party receives the busy tone after dialing the called party's number and disconnects. The connector then allows the preceding switches to release and reseizes the calling line, applying the ringing code of the called subscriber. Once during each ringing cycle, a distinctive ringing signal is placed on the silent side of the line to indicate that a reverting call is in progress. When any party on the line answers the call, ringing is stopped, and the connector then provides transmitter battery to the called line. The stopping of the ringing signal indicates to the calling party that the call has been answered.

Certain types of connector release when the call is answered.

In harmonic ringing exchanges, since only the called party's bell will be rung on a harmonic ringing line, the calling party is instructed to wait a reasonable interval before re-entering the line after originating a reverting call, and a distinctive tone is placed on the line momentarily when the call is answered so as to inform the called party that he is answering a reverting call and should wait on the line for the calling party. This tone also serves to advise the calling party that his call has not been answered and that he must call again, should he re-enter the line before the called party.

218 (d) Code Ringing:

(A) Two Codes Only (1 Ring - 2 Rings): This simple code ringing scheme works on a terminal per station basis, the lines being served by two groups of connectors. The banks of both connector groups are in multiple. The connectors in one group give the usual long intermittent ring ( - - - etc.), while the connectors in the other group give a short two-ring code (-- -- --, etc.).

In order that the desired code may be selected by the third figure from the last in the directory number, access to each group is obtained by way of a different level in the banks of the preceding selectors. The connectors in the "1-ring" group may be the regular straight line connector discussed in Sec. 205 (a); but the connectors in the "2-ring" group must be a "Two-Ring Connector" as described below.

The above scheme provides 4-party semi-selective service.

(B) The Two-Ring Connector: The interrupted generator (battery connected) fed to this switch has been coded by the ringing interrupter to give a two-ring code (-- -- --, etc.). The only novel feature in this connector is the provision of a "pick-up lead" to insure that the ringing will start at the beginning of the next code, and not in the middle of a code. This feature is present in all code ringing connectors.

Code Selecting Connectors: A code selecting nector is similar in appearance to the regular nector with the addition of a code selecting mec- ism consisting of a minor switch. The circuit is rranged that the proper ringing code is selected a digit dialed before or after the vertical and rot- operation of the connector shaft.

ny connectors of this type discussed in Sec. 218 (b) may be used either as a frequency or code sel- ng connector.

10-Party Code Selecting Connector, Frequency, t: In this connector the impulses of the code sel- ng digit rotates a minor switch to the desired ttact. The top wiper selects both the code and the e of the line to be signaled.

n even number is dialed, the connector will ring r the "+" side of the line, while if an odd number e dialed, the connector would ring over the "-" e of the line.

tter the dialing of the last digit, the connector will rt to ring at the beginning of the code next to fol- an impulse received over the pick-up lead.

Delayed Ring: In small telephone exchanges when toll train may be omitted as an economy measure, oll operator, when calling into a code ringing con- tor group, may find it desirable to call two digits us making the called line busy to other calls), but aying the dialing of the last digit until she is ready complete the connection.

rtain connectors are arranged so that the toll op- ator may at this time monitor on the called line,

8 (e) For further information regarding party line rvice see AT (Meyer) 4-19.

9 to 276 - NO COMMENT.

7 The Line Switch: Lineswitches, both plunger and tary, began to fade out of the picture in the late 20's. The following quotation from the Bell Labor- ories' Record (Dodge) 2-29, is of interest: "The velopment of the line finder to replace the line vitches illustrates a trend, noticeable in other Bell stem developments of dial apparatus, to replace a rge number of small mechanisms by a smaller mber of more inclusive ones." Nice wording, any ay you take it.

8 The Keith Line Switch: Those who did not grow with the plunger line switch may be pardoned for a ertain amount of skepticism regarding its worka- lity, for it certainly is a wild and weird contrivance.

he plunger line switch was the original "cross bar," d was thus described in Smith & Campbell: "In e Keith type line switch, the relation of the sub- cribers' lines to the trunks may be illustrated by nes crossing each other at right angles in Fig. 1 (of this section). Each subscriber's line is shown as extending across the trunks, indicating the possibility

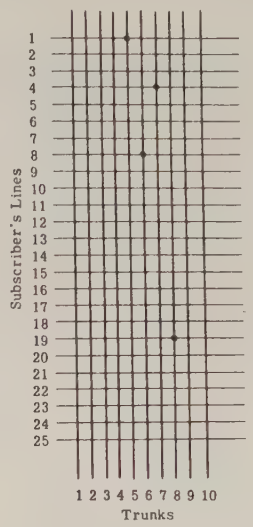



Fig. 1 - Relation of Subscribers' Lines to Trunks in Plunger Line Switch.

of connection with any of them. The heavy spots show connections which have been made by subscribers in putting through their calls. Line 1 has been connected to trunk 5, line 8 to trunk 6, line 4 to trunk 7, and line 19 to trunk 8."

"In its mechanical structure the Keith type line switch is essentially a number of switches with a portable handle. The idea shown in Fig. 2 (of this

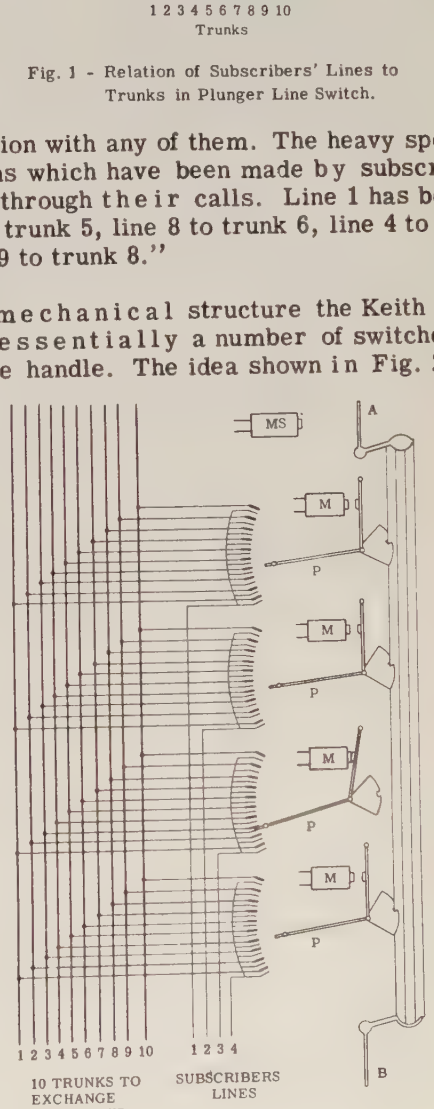



Fig. 2 - Principle of Plunger Line Switch.

section). The portable handle is called the "plunger" and is carried on the end of a lever called the "plunger arm."

The Keith line switch was not only workable but also economical, and was the one thing that "proved in" the Strowger system. Its temporary eclipse may be largely laid to politics.

278 (a) The 3-Wire Line Switch: The 3-wire system was developed during "local battery" days, and naturally the designers could not consider any device which required "holding current" during the time of conversation. The 3-wire Keith line switch is described here because it well illustrates the ingeniousness of the early designers, and brings up a point which may be of value in the future.

This switch as shown in Fig. 1, is built upon the principal of the "Figure 4 rabbit trap." The plunger

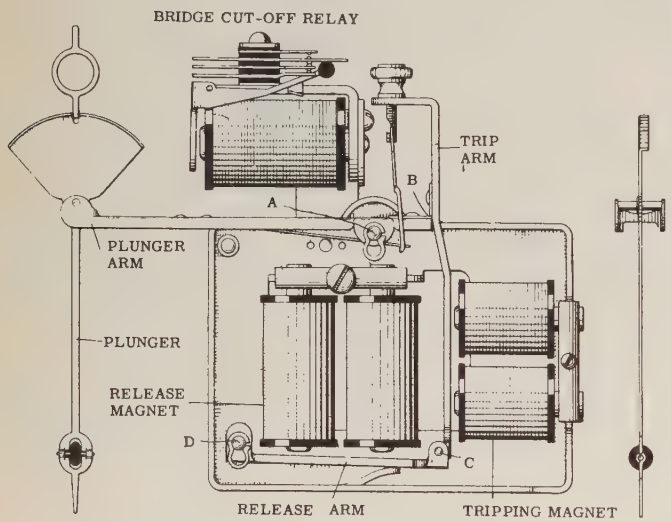



Fig. 1 - The 3-Wire Line Switch.

arm (pivoted at A) would force the plunger into the bank under spring tension were it not latched to the tripping arm at B. The tripping arm (pivoted at C) may be moved vertically by the release arm (pivoted at D).

The removal of the receiver in the 3-wire system was without effect but, each time the dial was pulled off normal, a "preliminary rotary" pulse was sent over one side of the line. The first preliminary rotary pulse actuated the associated tripping magnet and caused the trip arm to free the plunger arm, thus causing the plunger to enter the bank.

When the receiver was restored, at the end of the conversation, the switch hook momentarily grounded both sides of the line. The release magnet, in response thereto, raised the trip arm to a position somewhat above that occupied by the short end of the plunger arm. The release magnet de-energized at the end of the pulse and the trip arm, upon engaging the plunger arm, caused the latter to remove the plunger from the bank.

Some young circuit designer, who still believes in Santa Claus, should be able to apply this tripping principal to all-relay boards and thus save the hea current drain which is characteristic of that syste

278 (b) The Single Coil Line Switch: The single c line switch, shown in Fig. 2, was the first of t

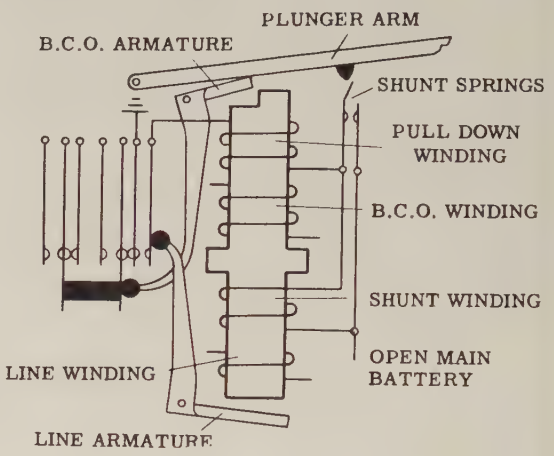



Fig. 2 - The Single Coil Line Switch.

2-wire line switches and utilized a B.C.O. winding hold the plunger in the bank during conversatio There were four windings and three armatures ass ciated with the single core. If the magnetic circu between the core and the frame of the switch wa perfect (it often was not), the switch worked as i intended.

The line winding was energized upon the removal the receiver, thereby closing a series circuit throug the pull down winding and shunt winding to open ma battery. The pull down winding actuated the plunge arm to force the plunger into the bank and to operat the shunt springs, at the same time the B.C.O. arma ture operated its associated spring assembly to c off the line winding. The short circuiting of the shu winding produced a slow acting effect which main tained the line armature energized until holdi ground could be returned from the switch ahead t energize the B.C.O. winding. If the magnetic cir cuits were not perfect, flux leakage from the pu down winding would hold the line armature operate and the switch would burn up.

278 (c) The Two Coil Line Switch: The two co line switch, shown in Fig. 2, Sec. 178 (a), has as th second coil a slow to operate and slow to release lin relay (slug on armature end of core). Line switche of this type had been operating satisfactorily for sev eral years when Newforth returned from England wit the story that in European practice all copper slug were mounted on the heel end.

None too much was known about the theory of slo acting coils at that time and Martin, in one of his fe weak moments, put through a blanket change orde changing all slugs to the heel end. Shortly thereafte the original order for Tampa came through and 200 line switches were made up, only to find they wer inoperative.

e of the young technical men may enjoy digging ne theory involved in sections 278 (b) and 278 (c); n brings to mind Clare's famous remark: "Those [illegible]. men sure know their theory, but it isn't safe rust them with a screw driver and hammer."

urther discussion of slow acting relays, see Mitchell) 2-20 and AT (Clapham) 10-20.

d) The Self-Aligning Line Switch: The line-hes above described remain where used until naster switch picks up idle plungers. This will ccur until enough calls have been made to cause guide shaft to pass the trunk where the idle er is resting, or a secondary shelf has become (see "secondary line switches"). If the traffic ht, one subscriber who makes several calls will use the same trunk over and over. It also oc- fortunately not very often, that two subscribers during the sweeping motion of a master switch. , when the open main closes, both subscribers ne same trunk resulting in a "double connec- "

ble plunging" was the bug-a-boo of the Keith switch. It didn't happen very often but, as there nothing else wrong with the switch, that was the point talked about. Note that it was not a matter tting in on a talking connection, as happens when ector gets in on a busy trunk, but merely a mat- f each subscriber tying up the other until both up. If double plunging is the cause of actual laint, rather than mere conversation, it can be y obviated by running a chain circuit through all switches in the group, thus preventing more than ineswitch from operating at precisely the same nt.

plunger of the Type 27 Lineswitch is self-align- which means that it automatically aligns with lungers of the free or idle lineswitches of the when released from the bank, without action on art of the plunger guide shaft. Master switch rol of the plunger guide shaft, however, is re- ed to step the non-engaged plungers to line up free bank trunks as the trunks become busy.

self-aligning action of the plunger is accom- hed by means of two members, or arms, inde- ently pivoted to the bearing hub of the plunger, normally held in close parallel relationship with other by means of a spiral spring. The tips of two parallel arms of the plunger are fitted with lated rollers which normally engage opposite s of the tongue, or spline, of the plunger guide , and the spline of the plunger guide shaft is of icient width to include the line of travel of the ger when it enters and releases from the bank. dition to engaging the spline of the plunger guide ft, the two arms also normally engage opposite es of a projection, or stop, on the outer edge of kirt of the plunger. Whenever the plunger is not ged in the bank, the tension of the spiral spring ps the two arms in contact with both sides of the e of the plunger guide shaft and the skirt stop of the plunger, and consequently, the plunger is stepped along the arc of the bank and lined up with free trunks as the plunger guide shaft is moved by the master switch.

Whenever the plunger is engaged in the bank, one arm will be in contact with one side of the skirt stop of the plunger, and the other arm will be in contact with the opposite side of the spline of the shaft, or vice versa, as the plunger guide shaft is stepped around. The action of the spiral spring permits the spreading and converging of the two arms as the relationship of the engaged plunger and the plunger guide shaft changes. As the plunger releases from the bank, and its tip clears the bank comb, the spiral spring draws the two arms together, and, since the arm in contact with the skirt stop of the plunger is the arm that is free to move, it carries the plunger with it until it comes in contact with the spline of the plunger guide shaft. Thus the plunger is lined up with all other non-engaged plungers of the group.

The idea of a self-aligning plunger line switch is very old, dating from 3-wire days, but always this difficulty developed, "what would happen if a subscriber re-called before his plunger had time to line up with the shaft?" They were tried out several times, and in each instance had to be given up, because the double plunging would be into a talking connection. Gould finally hit upon the idea of incorporating a time delay which would insure that the plungers were lined up before they could enter the bank.

The self-aligning plunger line switch is of undoubted value when used in unattended light traffic exchanges, where otherwise a subscriber might get on a defective trunk and remain there for hours before the master switch picked him up.

278 (e) For further information regarding plunger line switches, see A.E.Co. Bul. 305 and Bul. 805.

279 The Rotary Line Switch: The use of rotary line switches is not advisable in systems which require the preselecting of trunks. The homing type of switch cannot be made preselecting, and the non-homing should not be made preselecting for the following reason.

The distinguishing feature of a rotary line switch system is the rather husky motor magnet (approximately 100 ohms) required for each line, as compared with the master switch solenoid (45 ohms) which is common to perhaps one hundred lines.

Assume that a group of 250 twenty five point non-homing rotary line switches (10% trunking) is made preselecting. It is now quite possible that 249 one hundred ohm motor magnets will kick off when the next call is made. The current drain would be tremendous.

The post selecting feature of the rotary line switch is not as bad as it sounds, because of the fact that, in practice, a given line switch will engage the trunk

upon which it is standing in a large percentage of initiated calls.

An interesting proof of the pudding would be to take sound-level measurements, during the busy hour, before (1) a plunger line switch board, (2) a rotary line switch board, and (3) a shelf of Strowger line finders.

In Fig. 1 is shown one form of the mechanical interlock which must be provided between line and cut-off relays associated with rotary line switches.

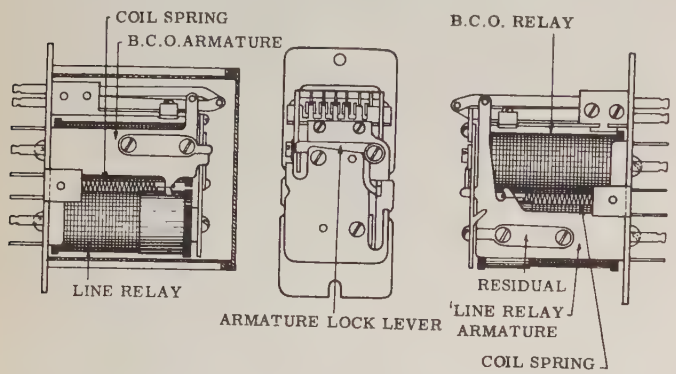



Fig. 1 - Interlocking Relays, Rotary Line Switch.

280 The Secondary Line Switch: It is very unlikely that plunger type secondary line switches will ever again be used, but there is some nice theory involved which should be understood by one seeking a general knowledge of the art.

When plunger type primary and secondary line switches are employed, the lines terminate on primary line switches which have access to a group of trunks terminating in secondary line switches. The secondary line switches, in turn, have access to a group of trunks leading to selector switches.

Let us assume the presence of 1000 primary line switches (10 boards of 100 line switches each) arranged for 10% trunking. The 100 outgoing trunks will terminate on one hundred secondary line switches which are mounted ten in a section, each section being controlled by a master switch. We will further assume that the first eight trunks from the banks of each section lead to first selectors, the two remaining trunks being permanently made busy. Thus 80 first selectors will handle the traffic originating from 1000 lines.

Not more than one trunk from a primary board goes to a given secondary section. The first trunk from the first primary board runs to the first secondary in the first secondary section, the second trunk goes to the first secondary in the second secondary section, etc. This is the basic principle of the trunking By giving each primary board a trunk into each of the ten secondary sections all of the eighty selectors are made available to all the subscribers. If all of the outgoing trunks from a given secondary section become inoperative, it renders useless not more than one trunk from each primary board.

The trunking between the primary line switch ba and the secondary line switches is done in accorda with a definite mathematical plan, which is shown Fig. 2. The primary boards are numbered at left, and secondary sections at the top. The numbe inside the squares are the numbers of the outgo primary trunks from each board. Each trunk ter inates in a secondary line switch which is mount on the secondary section indicated by the numb appearing at the top of the column. Primary boa No. 1 is distributed in strict numerical order, t trunks from the other boards are distributed accor ing to the following scheme.

That trunk, from each primary board, which term nates in a secondary line switch in section No. 1 the trunk whose number corresponds to the numb of the primary board. The trunks which go to se ondary sections 2, 3, 4, 5, etc., are chosen by addi the number of the primary board to itself succes ively. Thus in primary board No. 2 the trunks succession lead to secondary sections 2, 4, 6, 8, a 10, but when this addition, carries the number beyo ten the trunk taken is one less than that indicate For instance, passing two trunks beyond 10, we shou arrive at trunk No. 2 but in reality trunk No. 1 is take

TO A SECONDARY LINE SWITCH MOUNTED ON SECTION SHOWN ABOVE

| PRIMARY BOARDS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| | TRUNK 1 | TRUNK 2 | TRUNK 3 | TRUNK 4 | TRUNK 5 | TRUNK 6 | TRUNK 7 | TRUNK 8 | TRUNK 9 | TRUNK 10 |
| 1 | 2 | 4 | 6 | 8 | 10 | 1 | 3 | 5 | 7 | 9 |
| 2 | 3 | 6 | 9 | 1 | 4 | 7 | 10 | 2 | 5 | 8 |
| 3 | 4 | 8 | 1 | 5 | 9 | 2 | 6 | 10 | 3 | 7 |
| 4 | 5 | 10 | 4 | 9 | 3 | 8 | 2 | 7 | 1 | 6 |
| 5 | 6 | 1 | 7 | 2 | 8 | 3 | 9 | 4 | 10 | 5 |
| 6 | 7 | 3 | 10 | 6 | 2 | 9 | 5 | 1 | 8 | 4 |
| 7 | 8 | 5 | 2 | 10 | 7 | 4 | 1 | 9 | 6 | 3 |
| 8 | 9 | 7 | 5 | 3 | 1 | 10 | 8 | 6 | 4 | 2 |
| 9 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| 10 | | | | | | | | | | |

Fig. 2 - Magic Square

The effectiveness of this method in scattering traffic is shown by arranging a table giving the secondary sections which will receive traffic after all of the primary master switches have moved away from a trunk leading to a given secondary section. Let us suppose that each primary master switch is standing opposite that particular trunk which leads to secondary section No. 5. If this section becomes busy and

rimary master switches each drop back one the distribution will be as follows:

ry board No. . . . . 1 2 3 4 5 6 7 8 9 10
iated master switch is
anding in front of trunk
g to secondary section
. . . . . 4 10 1 2 7 3 8 9 6 6

) Pick-Up Circuit: If all of the outgoing from a given secondary section become busy not sufficient to merely ground the contacts in rimary master switch banks which are associ- with the trunks to this section of secondaries, is also necessary to operate all the primary r switches in the thousand so as to pick up any witch which may happen to be standing opposite k to the busy secondary section.

289 NO COMMENT.

ocal Test Desk: The local test desk provides all es ordinarily required to make tests on a Strowger n. The equipment includes, (1) a volt-ohm-milli- (VOM) for locating and determining non-standard ting conditions, (2) a dial speed and pulse ratio and associated equipment for use in testing the g speed and percent make of subscribers' dials, heatstone bridge for making accurate resistance urements, and (4) provision is also made for ting a transmission test set to a line or trunk test.

Classes of Calls: (1) Incoming; (a) from other ors via "in" call wire circuits, (b) from selector . (2) Outgoing; (a) to other desks via "out" call circuits, (b) to Automatic subscribers via the ice" cord circuit and associated line equipment, Automatic subscribers via the test distributor and the test switch train, (d) to Automatic sub- rs, trunks, common battery or magneto lines, via t line to the MDF.

coming Calls To Test Desk:

Incoming Call Wire: The incoming call wire les a means of direct communication with the n. They are generally used for reporting trouble ipment, requesting instructions in regard to test nd for requesting verification of lines which show lly long busy periods.

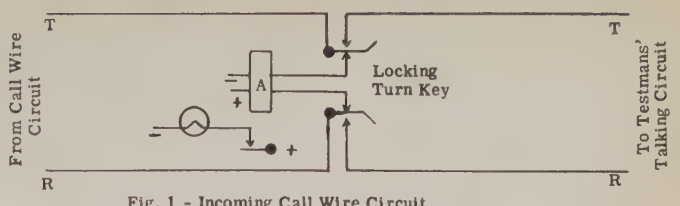


Fig. 1 - Incoming Call Wire Circuit.

An incoming call, see Figure 1, is indicated by the lighting of the associated lamp. Operation of the turn key connects the testman's talking circuit across the call wire.

291(b) Incoming From Selector Levels: One function of every Strowger trunking switch is to "hold" the preceding switches of the train. It follows that trunks from selector levels into manual boards must also be "held". The relay group in which a trunk terminates has sometimes been called a "repeater". This is unfortunate, as the term repeater usually means "impulse repeater". The relay group we are about to discuss does not repeat impulses, a more descriptive term would be "holding bridge".

(A) Inspector's Trunks: Inspector's trunks incoming from selector levels provide access to the test desk for testing purposes. The connection is customarily established by dialing a three digit number, see Section 157.

Refer to Figure 2 and note that this circuit is marked free in the selector banks by the absence of ground on the P conductor.

(B) Seizure: Relay A operates when the incoming loop is closed, (1) closes B, (2) closes ring back tone to the calling line, and (3) closes the answering lamp in series with an auxiliary alarm. Relay B operates to ground the P lead, thus holding preceding switches.

(C) Answering: (Operated; relays A and B). The testman acknowledges the call by inserting a plug into the jack of the calling trunk. Ground on the sleeve of the plug, by way of make springs in the jack, closes upper D in series with C. Relay D operates, locks its lower winding, opens the ringback circuit, opens the answering lamp and closes the hold lamp. Relay C operates, closes a multiple circuit to B, and removes A from the trunk. Relay A restores to open the hold lamp. The operation of the cord circuit "Talk" key enables the testman to converse with the calling party.

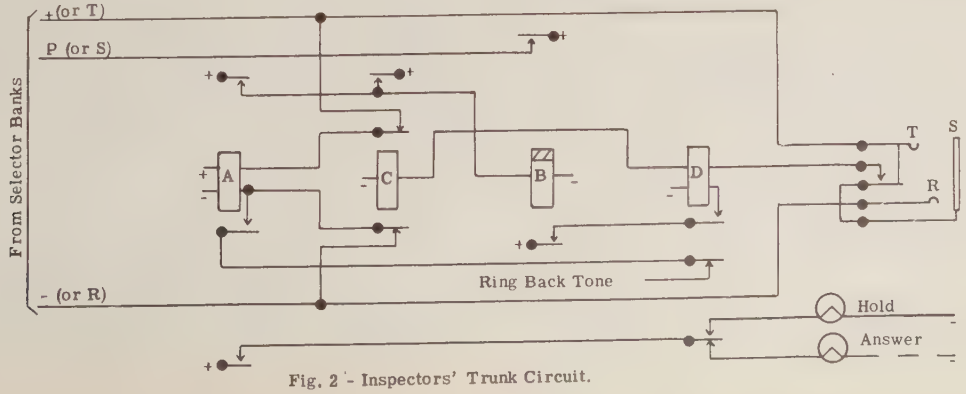


Fig. 2 - Inspectors' Trunk Circuit.

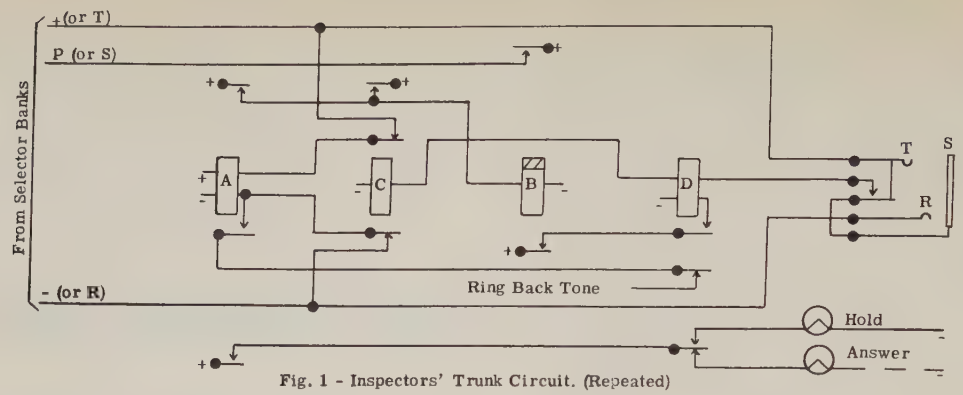



Fig. 1 - Inspectors' Trunk Circuit. (Repeated)

(D) Holding: (Operated; relays B, C and D). If the testman desires to withdraw from the connection temporarily, the plug is removed from the jack, (calling party still on the line). This opens upper D and C. Relay D remains locked up. Relay C restores, opens B and closes A. Relay A operates, recloses B and closes the hold lamp.

When the testman is ready to come back to the connection, he re-inserts the plug in the jack. Relay C operates to close B and open A. Relay A restores to open the hold lamp.

(E) Release: (Operated; relays B, C and D). When the calling party restores his handset, and the testman removes the plug from the jack, the circuit is opened to upper D and C. Relay C restores and opens B. Relay B restores, opens lower D, and removes ground from the P lead to release preceding switches.

(F) Recapitulation: The term "holding" has been used with two different meanings, (1) to return ground on the release trunk to hold preceding switches, and (2) to "lock up" the switch train so that the calling party cannot release the connection. This particular trunk circuit is somewhat unusual, (1) in that it extends the calling line, clear of attachments, to the test circuit, and (2) the release is under the control of the testman.

The usual holding bridge feeds battery to the calling party by way of a line relay. The line relay energizes a slow acting release relay which functions to return ground on the release trunk. The talking circuit passes through a pair of talking condensers, as in the connector.

292 Test Desk Cord Circuits: The test desk is equipped with three types of cord circuits, (1) the service cord, (2) the primary test cord, Section 294(a), and (3) the auxiliary test cord, Section 294(b).

292(a) The Service Cord: The stationary end of the service cord circuit is terminated on regular line equipment in the Automatic switchboard, no connector terminal is associated therewith. The service cord is used by the testman for, (1) answering incoming calls on jack ended trunks, (2) extending calls from incoming trunks via the regular switch train, and (3) establishing connections over the regular switch train.

(A) Incoming Call, Answering: To answer an incoming call the testman inserts the plug of the service cord into the trunk jack and operates his "Talk" key. Conversat is then established between the testman and the call party.

(B) Incoming Call, Extending: If it is necessary extend an incoming call to an Automatic subscriber, testman operates the above mentioned key from "Talk" to the "Dial" position. This prepares the circ for dialing and lights the cord supervisory lamp. T directory number of the desired subscriber is dialed the testman. The dial key is then restored. When called party answers, the cord supervisory lamp w darken.

When the conversation is completed and both parti retire from the connection, the cord supervisory la will light. The removal of the plug from the trunk ja restores the circuit to normal.

293 Outgoing Calls From Test Desk:

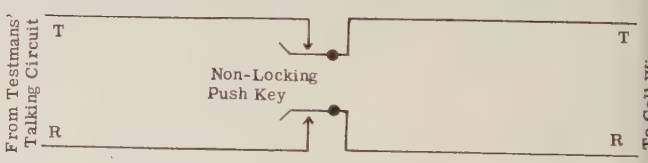



Fig. 2 - Outgoing Call Wire Circuit.

293(a) Outgoing Call Wire: The outgoing call wir provide connection to other desks or switchboards, s Figure 2. The push key connects the testman's talki circuit to the desired distant operator's positio

293(b) Outgoing Via Service Cord: Should the testma desire to establish a connection over the regular swit train, the associated "Dial" key is operated and th directory number of the desired party is dialed. Th operation of the dial key places a holding bridge acro the line to hold the switch train. Once this bridge placed across the line, it will not be removed by re storation of the dial key. This provision permits th testman to perform other duties while waiting for th called party to answer.

When the called party answers (supervisory lamp goe dark), or prior thereto, the testman may operate th "Talk" key. The operation of this key opens the lockin circuit of the bridge. When the conversation is complet restoration of the talk key opens the bridge, thus releasi the switch train.

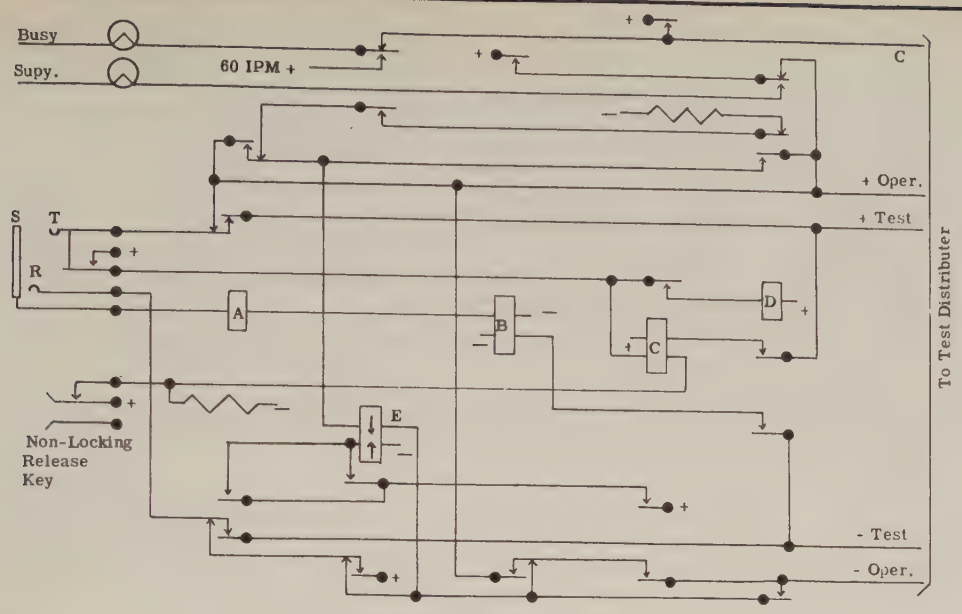



Fig. 3 - Trunk To Test Distributer.

Outgoing Trunk To Test Distributor: The outgoing to the test distributor provides the testman with for making rapid tests via the test switch train.

eizure: The testman inserts the plug of the primary ircuit, see Section 294(a), into the jack shown in e 3. High resistance ground, via the sleeve of the passes through A and upper B. The make contact of k closes lower C in series with a limiting resist-

C operates, (1) grounds the C lead to make this usy, (2) lights the busy lamp, (3) short circuits D, ) closes the "-" operating lead to the ring of the

A operates, (1) transfers the tip and ring of the jack he operating leads to the test leads, (2) closes erating loop through upper E, and (3) closes E.

E does not operate because its windings are ed. Relay B does not operate through the high ance. The circuit is now ready for dialing.

ialing: (Operated; relays A and C). When the dial ated with the primary test circuit is moved off l, a cord circuit relay opens the sleeve circuit.

A restores, (1) opens lower E, and (2) extends the ing loop to the dial impulse springs, by way of tip ng, before removing upper E from the operating As the dial returns to normal, the impulse springs nd close the operating loop to the test switch When the dial reaches normal, the sleeve circuit losed to A and B. Only relay A operates at this

esting: (Operated; relays A and C). Assuming a ory number has been dialed, the primary test t is now extended through to the line circuit under ne BCO has operated, the line is free of attachments e usual "out" tests may be made.

(C1) "In" Test: If the testman desires to test in toward the switchboard (sometimes called a "bridge cut-off test"), he actuates the "BCO" key associated with the primary test circuit, this places direct ground on the sleeve of the jack.

Relay B now operates from its upper winding, places direct ground on both operating leads and short circuits upper E. Relay E will not operate on its lower winding alone. The placing of ground on both operating leads causes the test train to function so that the BCO of the called line restores to reconnect the associated line relay. A deflection of the VOM needle indicates to the testman that the line circuit of the called line is prepared for seizure. The testman then momentarily operates the "Call Through" key of the cord circuit, this will connect the dialing circuit across the line under test. As soon as dial tone is received, the desired number is dialed. The impulses sent out by the dial may be observed by the deflection of the VOM needle. After dialing is completed, the "BCO" key is restored to normal, and the "Primary Talk" key is operated.

(C2) Permanent Disconnect: In the event there is a "Permanent" on the line, the operation of the "BCO" key associated with the primary test circuit will cause the release of the permanent - provided the test distributer is arranged to give "permanent disconnect". See Section 412(a)(F3).

(C3) Monitoring Subscriber's Call: In case a subscriber reports difficulty in dialing, and tests fail to reveal any trouble on the line, the subscriber's set, or in the central office equipment, it is often desirable to monitor at the test desk, so the testman may observe the circuit while the subscriber attempts to dial a desired number.

To perform this test, the line is seized via the test switch train. After the line under observation is signalled, the "Talking Battery" and the "Primary Talk" keys of the primary test circuit are operated in order to converse with the subscriber. The testman instructs the subscriber to dial the desired number. Prior to dialing, the "Talking

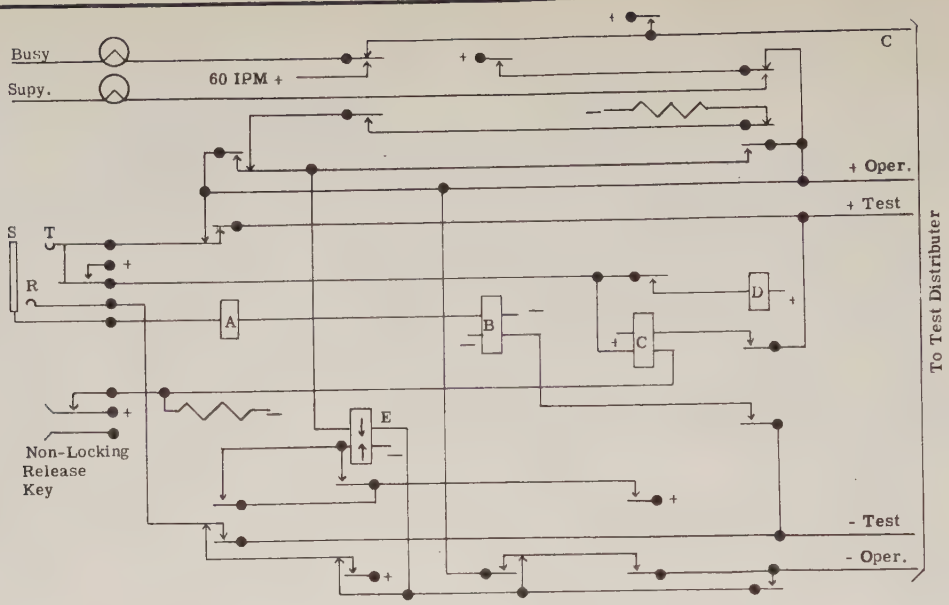



Fig. 1 - Trunk To Test Distributer. (Repeated)

Battery" key is restored to normal and the "BCO" key is operated momentarily. The momentary actuation of the BCO key allows the line equipment, associated with the line under test, to operate and extend the connection by way of a finder to a first selector. Dial tone will be heard by both the testman and the subscriber. With the "Primary Talk" key operated the testman may monitor without interfering with the subscriber's dialing.

(D) Dialed Test Connector or Dialed Line Busy: (Operated: relays A and C). In the event the line to be tested is busy, the testman may, (1) cut in on the busy line by merely operating the "Primary Talk" key of the primary test circuit, (2) release the test connector, see Subsection (G) below, or (3) wait until the called line becomes idle. In the event the test connector or dialed line is busy, the test switch train will reverse polarity over the operating leads to upper E.

Relay E operates, (1) locks its lower winding, (2) extends 60 IPM ground pulses to the busy lamp, thus giving a "flash busy" indication to the testman, and (3) prepares a circuit which will cause the ring to be grounded at the next de-energization of relay A. The testman may now dial the digit "one" to advance the wipers of the test connector from the busy line to the next line on the level. This allows the testman to test another line instead of waiting until the line previously dialed becomes free. When a busy connector has been encountered, the operator will also receive an audible busy signal.

(E) Holding Connection When Test Connector is Busy: (Operating; relays A, C and B). In the event that the testman wishes to retire from the circuit to wait for the test connector to become free, he may remove the test plug from the jack without releasing the test switch train. Removing the plug from the jack opens A and removes the shunt from D.

Relay D operates in series with lower C and the limiting resistance, (1) bridges E across the operating leads to hold the connection, (2) prepares a circuit to the supervisory lamp, and (3) prepares a circuit to lower B.

Relay A restores, (1) transfers the tip from "+" test to "+" operating, and (2) transfers the ring from "-" test to ground at make springs on E.

When the busy test connector becomes free, normal polarity will be restored to the operating leads, thus "bucking down" relay E.

Relay E restores, (1) extends the busy lamp to the C lead to obtain a steady glow, thus indicating to the testman that the connector has become idle, (2) opens its lower winding, and (3) transfers the ring from ground to "-" operating.

The testman may now re-insert the test plug into the trunk jack, which again closes A and upper B, and shunts D. Relay A functions as described above. Relay E restores and opens a multiple circuit to "-" operating from the ring.

(F) Holding Connection On Idle Line: (Operated; relays A and C). The testman may retire from this connection by removing the test plug from the jack without releasing the test switch train. The relay operation of the trunk circuit is the same as described above. When the called party removes his handset, a loop will be closed across the test leads. Battery is fed to the loop through lower B and ground is fed to the loop through upper C. Relay A closes the supervisory lamp as an indication that the called party is on the line. The testman may return to the connection by re-inserting the test plug in the jack.

(G) Releasing Test Connector From Busy Line: (Operated; relays A, C and E). To release the test connector only, the testman momentarily operates the "Connect Release" key of the primary test circuit. This operation places resistance battery on the tip and removes ground from the sleeve.

Relay A restores, (1) reconnects the tip to "+" operating, (2) reconnects the ring to ground at springs of E, and (3) extends battery through a resistance to upper

time there is resistance battery on both the "+" "-" operating leads. Battery on the "+" operating rrom the tip, causes the test distributer to open gp to the test connector. The test connector now es, and the test distributer reverses polarity on the ng leads.

E restores (because battery is present on both als of its upper winding), (1) transfers the busy o the C lead to obtain a steady glow, and (2) es ground from the ring.

ne testman restores the "Connector Release" key, is removed from the tip and ground is replaced on eve. Relay A reoperates and performs the ns described above.

lease of Test Connector Only: (Operated; relays A It is often desirable to make routine tests on all evels served by a particular test connector. The ion is first extended to line "11" in the hundred ested. The testman may now advance the test or one step by dialing the digit "1", and so on tne first level.

11 lines in the level have been tested, the testman arily operates the "Connector Release" key of nary test circuit. This causes the test connector se, but holds the test distributer operated. After g the connector release key to restore, the dials "21". This raises the wipers of the test or to the second level.

ration of the "Connector Release" key places ce battery on the tip, opens the ring and removes from the sleeve to open A. Relay A restores, ects the tip to "+" operating, and (2) connects the "-" operating. This causes the test distributer se the test connector

ase of Test Switch Train: (Operated: relays A To release the entire switch train, the test plug ed from the trunk jack, this opens A and upper B, oves the shunt from D.

operates in series with lower C, extends "+" g to the upper winding of E, and closes a multiple rom "-" operating to the ring.

restores, (1) transfers the tip to "+" operating, s lower E, and (3) transfers the ring to "-" g.

man now operates the non-locking "Release" key, nort circuits lower C and D. Relays C and D the busy lamp is extinguished, and the trunk is at

Test Line to MDF: The test line to the MDF means for making tests on lines and trunks at distributing frame. At the MDF, a "test shoe" ded for establishing connection between the and the test desk. At the test desk, this circuit es in, (1) a bridging jack for listening, and (2) in ff jacks so that the "line" side of the circuit may be tested independently of the "switchboard" side, and vice versa.

When it is desired to test a line at the MDF, the testman gets in on the MDF order wire circuit and asks that the test shoe be plugged in on a certain protector pair. This operation loops the line through the cut-off jacks at the test desk, and extends the heat coil side of the line through the jacks at the test desk.

When it is desired to monitor on the line before testing, the testman inserts the plug of the "primary test" cord into the bridging jack designated "Listening". This connects the line, in series with the heat coils, through the testing cord circuit, and the testman may monitor without interrupting conversations by holding the "TCO" key of the cord circuit operated, then operating the "Primary Talk" key.

If the testman desires to test the heat coils, he may do so by performing the usual voltmeter test with the plug of the testing circuit inserted into the "Listening" jack.

When the testman desires to test the line side of the circuit for grounds, shorts, etc., the plug of the test cord is inserted into the "Line" jack. This disconnects the switchboard side of the circuit and extends the line side through to the testing circuit.

Should the testman desire to test the switchboard side of the circuit, or test the operation of the apparatus associated with the line under test, the plug of the test cord is inserted into the "Switchboard" jack. This disconnects the line side of the circuit and connects the switchboard side through to the test circuit.

294 Test Circuits: All of the testing equipment is associated with one or the other of two testing cords, (1) the primary test cord, (2) the auxiliary test cord.

294(a) Primary Test Cord: In the primary test cord circuit are grouped those testing features which are necessary for making routine tests and other tests inseparably associated with the VOM. The primary test circuit is also arranged so the line or trunk under test may be connected to a portable wheatstone bridge or to a transmission test set by the operation of appropriate keys.

The primary testing cord circuit is designed for, (1) answering incoming calls from selector level trunks for information or complaint purposes, (2) for performing tests on subscriber's line circuits via test distributer trunks, (3) for performing tests on subscriber's lines, inter-office trunks, or other trunking equipment terminating on the MDF, via test lines to the MDF, and (4) for performing tests on Automatic subscriber's lines via selector level trunks.

294(b) Auxiliary Test Cord: In the auxiliary test cord circuit are grouped those features which do not involve the use of the VOM, the wheatstone bridge or the transmission test set, such as, (1) howler, (2) dial speed and pulse ration meter, etc.

294(c) Interchange Key: By operating the test cord interchange key designated "Switching", the primary and auxiliary testing circuits can be interchanged with respect to their cords, This arrangement eliminates the necessity of pulling down cords, and makes for rapid tests during rush periods.

295 Tests: The test desk is arranged to make the following tests.

295(a) With Primary Test Cord: (1) loop test without battery (VOM 0-600 scale), (2) loop test with battery (VOM 0-150 or VOM 0-15 scale), (3) test for ground on ring ("-" line), with battery (VOM 0-150 or VOM 0-15 scale), (4) test for ground on tip ("+" line), with battery, (VOM 0-150 or VOM 0-15 scale), (5) test for "-" potential on ring ("-" line) without battery (VOM 0-600 scale), (6) test for "+" potential on ring ("-" line), without battery (VOM 0-600 scale), (7) test for "-" potential on tip ("+" line), without battery (VOM 0-600 scale), (8) test for "+" potential on tip ("+" line), without battery (VOM 0-600 scale), (9) test station condenser with battery (VOM 0-150 scale), (10) make loop resistance measurements 0-50,000 ohms, 0-5,000 ohms, or 0-500 ohms, (11) test voltage of testing batteries, (12) make ringing tests, (13) make transmission tests, (14) test line equipment bridge, no battery, (VOM 0-600 scale), (15) test with wheatstone bridge, and (16) make insulation breakdown test.

295(b) With Auxiliary Test Cord: (1) Make ringing tests, (2) connect dial speed and pulse ratio circuit to line under test, and (3) connect howler to line under test.

296 Testing Combinations: The testing combinations used for determining the character of trouble consists of, (1) a 150 volt test battery, (2) a 15 volt test battery, and (3) a VOM having the following scales, (a) 0-600 volts, (b) 0-150 volts, (c) 0-15 volts, (d) 0-600 milliamperes, (e) 0-150 milliamperes, and (f) an 0-Inf. ohm meter, operate "OM-Low" key and read direct for resistances from 0 to 500Ω, operate "OM-Intr" key and multiply by 10 for resistances from 500-5000Ω, operate "OM-High" key and multiply by 100 for resistances from 5000Ω to infinity.

The 150 volt battery is used in connection with the 0-150 volt scales, and with the ohmmeter scales. The 15 volt battery is used with the 0-15 volt scale.

The 0-600 mil-ampere and the 0-150 mil-ampere scales are used in connection with the 48 volt exchange battery for making transmission tests, and also with the 200 volt battery for making insulation breakdown tests.

297 Testing:

297(a) Routine Tests Using Primary Test Cord: The routine tests are to be made by means of the 150 volt testing battery, in connection with the 0-150 volt scale of the VOM.

Routine tests are required generally to establish the fact that the line is devoid of shorts, ground, crosses with office battery or foreign EMF; that the continuity of line is complete; that the capacity of the line cor sponds to the number of stations connected thereto; that insulation resistance of the line is satisfacto

For the purpose of describing the various tests, it been assumed that a testing connection between the t circuit and the line to be tested has been established test distributor trunks, test line to MDF or some ot trunk or line arranged for testing. The testman sho not start any tests until the needle of the VOM come rest as the result of the completion of this connecti To do otherwise, is to introduce an error in the read of the instrument from a ballistic standpoint. Genera speaking, no test should be made until the needle of instrument comes to rest from deflection caused b previous test or some circuit change in the test connection.

(A) Loop Test With No Battery On Voltmeter: 0-600 volt scale of the VOM is normally connected the primary test cord, with the positive terminal of instrument connected to the tip (positive) line and negative terminal of the instrument connected to the r (negative) line. With this arrangement the testman, w all keys at normal, may determine as soon as connecti is established whether the line under test is connected battery, or he may take the voltage reading of a dist battery which may be connected to the test circuit means of a trunk or test line.

If desired, it is possible to change from the 0-600 sc to the 0-150 scale by operating the "Ohm Inter." k It is also possible to change from the 0-600 scale to 0-15 scale by operating the "Ohm Low" key.

The 0-600 scale, the 0-150 scale ("Ohm Inter." k operated) and the 0-15 scale ("Ohm Low" key operat can be used to test battery voltages up to the full scal (0-600, 0-150 and 0-15 volts respectively) such insulation breakdown battery, booster battery, et which are frequently used in modern telephone exchang

If, when making the above test, battery is encounter which causes the VOM needle to deflect in the wr direction, the reverse key (Rev.) may be operated permit reading the voltage. The reverse key revers the tip and ring sides of the test cord.

(B) Loop Test With Battery On Voltmeter: The "150 key operated connects negative 150 volt testing batte through the VOM and its associated resistors to the ri (negative) line and connects direct ground to the (positive) line.

On a normal line with a bridged ringer, the operation the "150 V" key should cause a momentary deflecti of the VOM needle. This indicates the presence of t condenser in the subscriber's ringer circuit. When t subscriber's ringer is connected between the ring s and ground, a similar momentary deflection is obtain (See (I) for capacity tests).

There should be no meter deflection on vacant lines, lines which have subscriber's ringers connected betwe the tip side and ground.

ly reading of the VOM needle indicates a closed or circuit, or a ground on the ring (negative) line. mplitude of the deflection indicates whether a short ound, or partial insulation breakdown, is being red.

the needle indicate a reading in excess of the battery, it is an indication that the ring (negative) f the line is crossed with a foreign positive al. (See (F) for testing of foreign potentials). er, the testman should never permit excessive s to be applied to the meter as it is a sensitive ment and is easily damaged.

any of the results of these tests indicate 15 volts , and a more accurate check is desired, the scale dropped to 0-15 by the operation of the "15 V" place of the "150 V" key. The testing arrange- ith the "15 V" key operated is exactly the same the "150 V" key operated, with the exception results are recorded on the 0-15 scale in lieu 0-150 scale.

he foregoing, it may be seen that these tests are nt; since they will give a simple, rapid indication condition of the lines, and quickly determine which equire further testing. Should any of the lines in the above manner show unusual results, and se cannot be definitely determined from these one of the following tests may be employed to ine the type of trouble encountered.

est For Ground On Ring (Negative) Line: To ine whether there is a ground on the ring (nega- ne, the "150 V" and "Grd." keys are operated. ction opens the tip (positive) line and connects volt testing battery through the VOM and its ated resistors to the ring (negative) line. A on the ring (negative) line will cause a deflection VOM needle. If the ground detected by the test resistance, so as to give a reading under 15 volts, r check may be obtained by operating the "15 V" ieu of the "150 V" key.

est For Ground On Tip (Positive) Line: To ine whether there is a ground on the tip (positive) e "150 V", "Grd." and "Rev." keys are operated. ction opens the ring (negative) line and connects 0 volt testing battery thru the VOM and its ated resistors to the tip (positive) line, causing ction of the VOM needle if a ground is present tip (positive) line. The "15 V" key may be ed in place of the "150 V" key to read voltages 15 V.

st For Foreign Negative Potential On Ring (Nega- ine: To determine whether there is a foreign e potential on the ring (negative) line, the "Grd." operated with all other keys normal. This action the tip (positive) line, grounds the positive al (+) of the VOM, and connects the negative al (-) of the VOM and its associated resistors to (negative) line. A deflection of the VOM needle s a foreign negative potential on the ring (nega- ne. The 0-600 volt scale is used for making this test in order to avoid injury to the meter. In the event the foreign potential is under 150 volts, and it is desirable to obtain a more accurate reading, the 0-150 volt scale may be connected into the circuit by operating the "Ohm Inter." key. Likewise, if the foreign potential is under 15 volts, the 0-15 volt scale may be used by operating the "Ohm Low" key.

(F) Test For Foreign Positive Potential On Ring (Negative) Line: In case the deflection of the VOM is in a reverse direction, that is "off scale", when the preceding test (E) is performed, the "FEMF" key is operated with the "Grd." key left in its operated position. This action connects ground to the negative terminal (-) of the VOM and its associated resistors, and connects the positive terminal (+) of the VOM to the ring (negative) line. A deflection of the VOM needle in the proper direction indicates foreign positive potential on the ring (negative) line. The 0-600 volt scale is used initially for making this test in order to avoid injury to the meter. After making the initial check on the 0-600 scale, a closer reading on lower voltages may be obtained by applying the method described under (E).

(G) Test For Foreign Negative Potential On Tip (Positive) Line: To determine whether there is a foreign negative potential on the tip (positive) line, the "Grd." and "Rev." keys are operated. This action opens the ring (negative) line, grounds the positive terminal (+) of the VOM, and connects the negative terminal (-) of the VOM and its associated resistors to the tip (positive) line. A deflection of the VOM needle indicates a foreign negative potential on the tip (positive) line. After making the initial check in the 0-600 scale, a closer reading on lower voltage may be obtained by applying the method described under (E).

(H) Test For Foreign Positive Potential On Tip (Positive) Line: In case the deflection of the VOM is in a reverse direction, that is "off scale", when the preceding test (G) is performed, the "FEMF" key is operated with the "Grd." and "Rev." keys left in the operated position. This action connects ground to the negative terminal (-) of the VOM and its associated resistors, and connects the positive terminal (+) of the VOM to the tip (positive) line. A deflection of the VOM needle in the proper direction indicates foreign positive potential on the tip (positive) line. After making the initial check on the 0-600 scale, a closer reading on lower voltages may be obtained by applying the method described under (E).

(I) Condenser Tests: To establish the fact that the capacity of subscribers' lines corresponds to the number of stations connected thereto, the following test is performed.

The "150 V" key is operated, which sets up a testing condition as outlined under (B). The "CT" key is then operated, starting an interrupter circuit which closes ground at specific intervals to the "condenser test" relay. This relay reverses the line when it is operated. The reversal charges and discharges the condensers bridged across the line through the meter; thus the VOM needle will remain deflected as long as the "condenser test" relay continues to reverse the line. The amplitude

of the deflection indicates the capacity across the line. This test is effective only when the condensers are bridged across the line.

(J) Resistance Measurement Tests: To insure the most accurate reading, the VOM should be set to zero by operating the "VMT" key and adjusting the rheostat "Vm. Adj.". To determine the loop resistance of a line, it is shorted at the station, and the "Ohm Hi." key is operated. The resulting VOM needle deflection is read in ohms on the "Ohms" scale, which, when multiplied by 100, will give the actual resistance. After making the first resistance check, a more accurate measurement should be made by operating the "Ohm Inter." key if resistance to be measured is from 500 up to 5000 ohms and, if the resistance is under 500 ohms, then the "Ohm Low" key is operated. The "Ohm Hi." key should normally be used for checking resistances from 5000 ohms to infinity. The "Ohm Hi." key remains operated during all resistance tests.

When a line tests short, after test (B) is made, and it is desired to determine the distance to the short, the foregoing test is made to measure the resistance of the loop to the short. This measurement is then translated to feet by using standard wire tables of ohms per miles covering the type of cable or open wire of the line under test.

The resistance of a ground on the ring (negative) line can be measured by making the above tests, except the "Grd." key is also operated.

For measuring the resistance of a ground on the tip (positive) line, the "Rev." is operated in addition to keys previously mentioned.

(K) Test Voltage Of 150 Volt Testing Battery And 15 Volt Testing Battery: When the testman desires to read the voltage of the 150 volt testing battery, the "150 V" and "VMT" keys are operated. The "150 V" key, when operated, connects the negative 150 volt testing battery through the VOM and its associated resistors to the ring (negative) line, and connects direct ground to the tip (positive) line. Operation of the "VMT" key opens the tip and ring of the test circuit towards the primary cord, and short circuits the tip and ring towards the meter circuit. The deflection of the VOM needle will indicate the voltage of the testing battery.

When the testman desires to read the voltage of the 15 volt testing battery, the "15 V" and "VMT" keys are operated. When the "15 V" key is operated, the negative 15 volt testing battery is connected through the VOM and its associated resistors to the ring (negative) line, and positive 15 volt testing battery is connected to the tip (positive) line. The "VMT" key, when operated, opens the tip and ring of the test circuit towards the primary cord, and short circuits the tip and ring towards the meter circuit. The deflection of the VOM needle will indicate the voltage of the testing battery.

(L) Ringing Tests: In order to test the ringer at the subscriber's station, or to signal a subscriber, a "Ring" key is provided. This key, when operated, connects ringing current through a 100 ohm, 30 watt, resistor in series with an 80 ohm polarized buzzer, to the ring (negative) line, and connects generator ground to the tip (positive) line. This test will operate ringers bridged across the line.

The 100 ohm, 30 watt, resistor is provided as protection against shorting the ringing mains in case the testman rings on a line of low resistance, or a line which is shorted, thus preventing interference with ringing at other desks or switchboard positions.

The 80 ohm polarized buzzer provides an audible signal, as an indication to the testman that he is ringing on a closed circuit. Failure of the buzzer to sound when the "Ring" key is operated indicates an open circuit.

The 800 ohm non-inductive resistance is connected across the buzzer in order that the circuit condition during the ringing period will be the same as when subscribers' lines are rung via the automatic switch train. This arrangement enables the installer or inspector to make subscribers' station ringer adjustments under true operating conditions.

The following party line ringer tests are for reference in the event the "Ring 1" to "Ring 5" keys are equipped.

In order to signal or test party line ringers, keys "Ring 1", "Ring 2", "Ring 3", "Ring 4" and "Ring 5" are provided. These keys, in the normal position, permit passage of ringing current for testing or signaling straight line ringers. Operating any one of the keys ("Ring 1" to "Ring 5") causes ringing current of the assigned frequency to ring the various harmonic ringers. Each ringing frequency is connected through a 100 ohm 30 watt resistor. The polarized buzzer is arranged in the circuit so it functions regardless of the ringing frequency being used.

If ten party divided ringing is required, a "Ring Rev." key is provided, which reverses the ringing mains so that the generator ground is on the ring (negative) line, and the ringing current is connected to the tip (positive) line. This will cause ringers connected to the tip (positive) line to operate. The ringers connected to the ring (negative) line are signaled with the "Ring Rev." key in the normal position.

(M) Primary Talking Circuit: Operating the "Prim. Talk" key connects the operator's circuit to the primary test circuit for supervising, or establishing communications with the subscriber, installer or trouble man.

Since most of the trunk and line circuits are not arranged to supply battery for transmission or supervisory purposes, it is necessary for the testman in most cases to operate the transmission battery key designated "T Bat." before the subscriber, installer, or trouble man can converse with the testman. Usually, the testman operates the "T Bat." and "Prim. Talk" keys simultaneously. The "T Bat." and "Prim. Talk" keys are located side by side so they can be readily operated in this manner.

PLEASE TURN TO PAGE 152, COL. 2

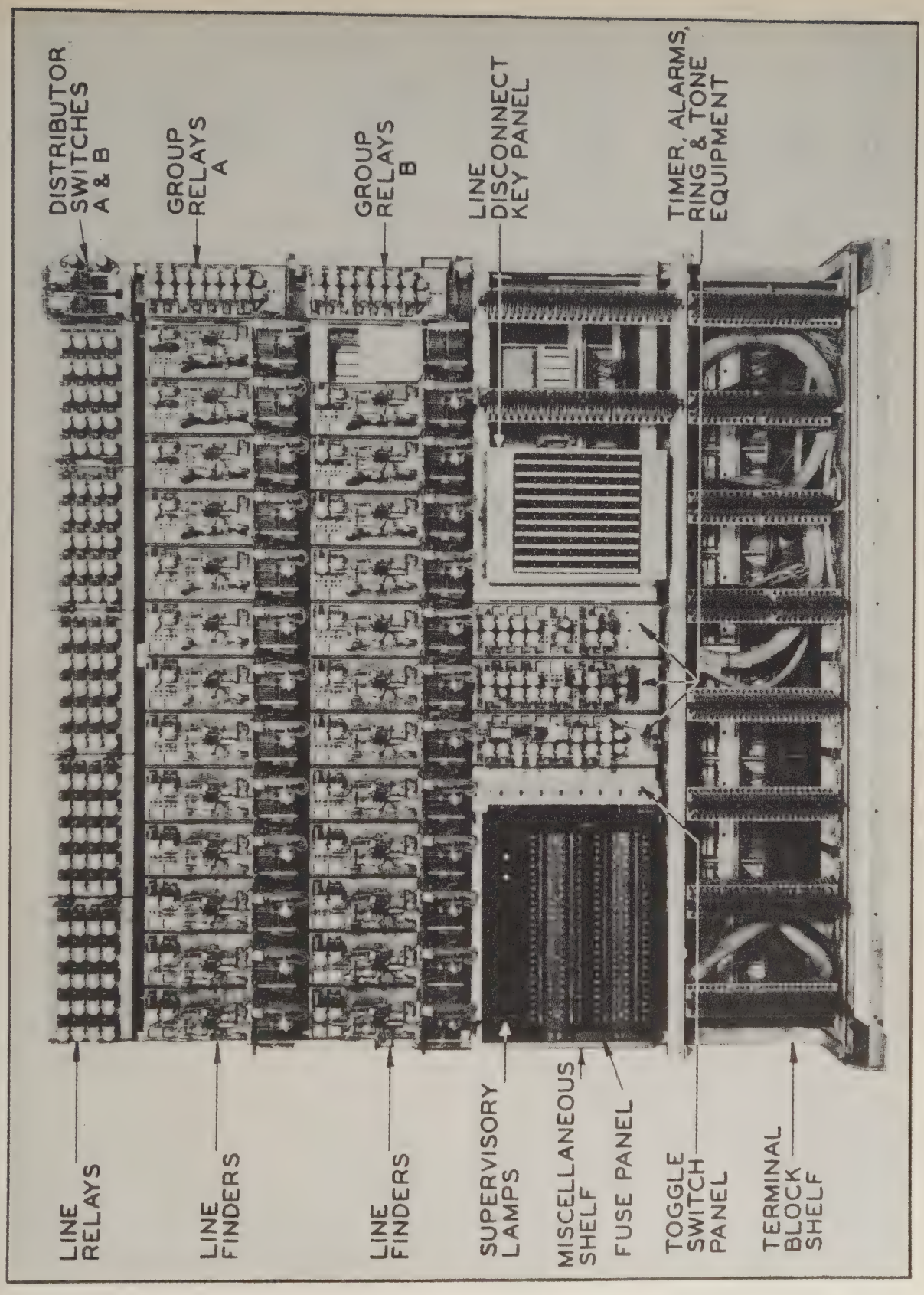



PLATE C - Line-Finder Side Of Board.

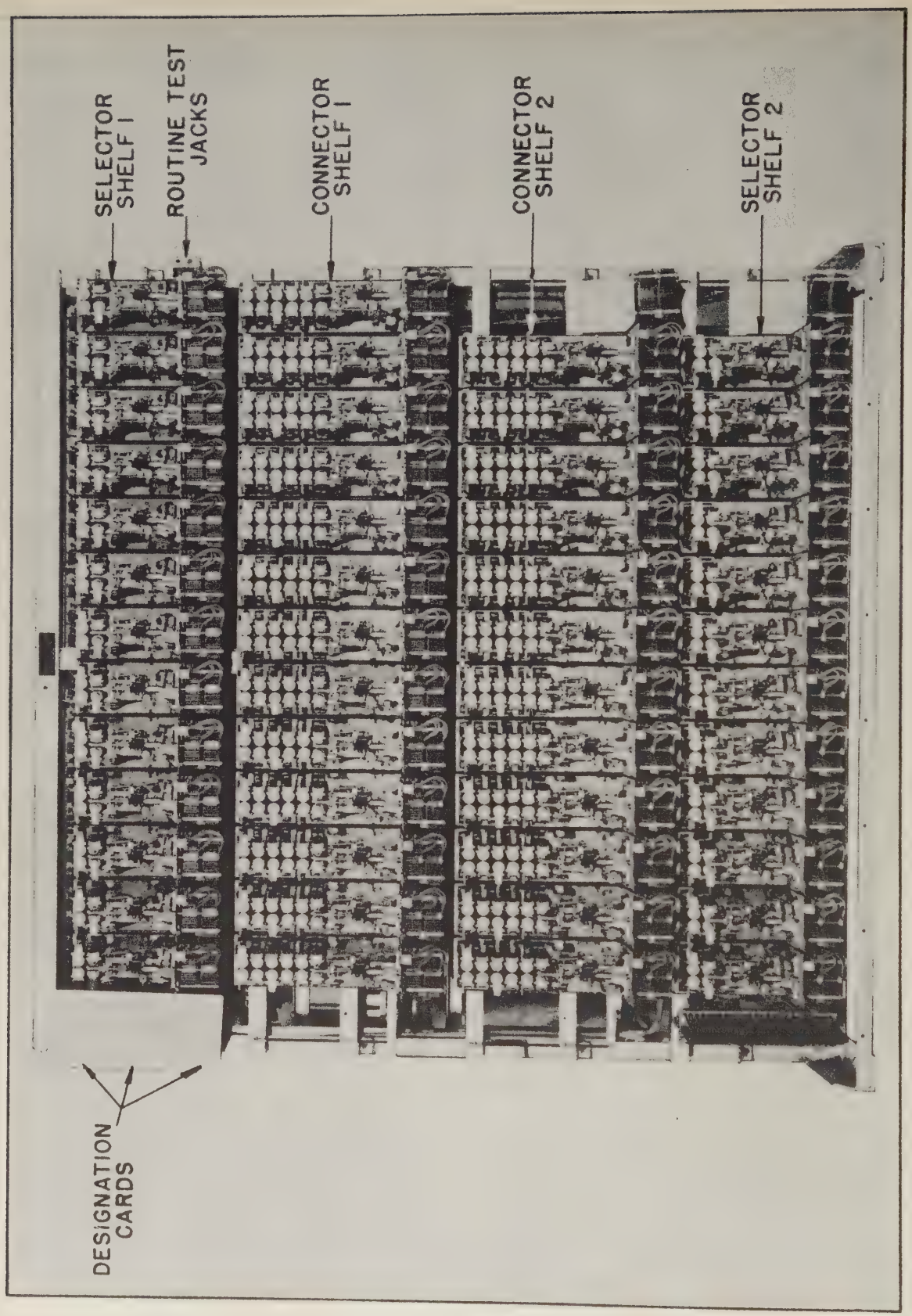



PLATE D - Selector & Connector Side Of Board.

# ART C - CIRCUIT KINKS

engineers maintain their own "Black Books" in is accumulated sub-rosa information over and that shown on official drawings, specifications his practice is usually frowned upon by manage- Perhaps they think that anything good enough black books should be in the official files.

the blackest of the writer's books contains over ndred vellum tracings of "Circuit Kinks." Boot- ints from these tracings were run off from time and somehow found their way into the field - they seem to be highly regarded. Circuit kinks little acorns from which big circuits grow. the writer's black book are original. Most of ave been stolen.

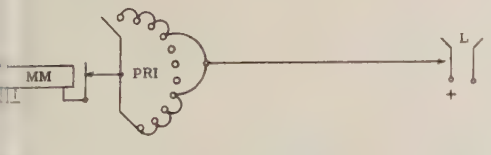
er Automatic is primarily a system of Remote l. The fact that the end use has to do with tele- s of little interest to anyone except transmission ers, and there aren't many transmission engi- If the reader has sufficient intestinal fortitude fully read and thoroughly digest the typical cir- nks shown below, he ought to be able to read any control circuit with considerable fluency. ne tenth of one percent might even become designers - who knows?

at each circuit kink covers one feature only, at a fine disregard is shown for unnecessary such as winding values, spark protection, etc.

arching Circuits: Searching circuits are es- y the same though they may appear as; (1) the action of a rotary line switch; (2) the rotary of a selector; (3) the rotary action of a trunk- ; connector; (4) the vertical and rotary action vel-hunting connector; or (5) the vertical and action of a line finder.

arching For Absence of Ground:

Switch Advances Upon De-Energization of Magnet: The conventions of Fig. 1 indicate a




g. 1 - Rotary Switch Searching For Absence Of Ground.

level rotary switch. The letters "PRI" that this is a private or control level, which that the tip of the wiper associated therewith ded so that adjacent contacts will be "bridged" as the wiper passes over the level. Levels shown without the letters "PRI" would indicate the use of a non-bridging wiper.

The depression of locking key L closes a circuit by way of the eleventh bank contact, and wiper standing thereon, through the self-interrupting springs to the motor magnet MM. The MM now energizes to open its own circuit, and, upon de-energizing, causes the double ended wiper to be advanced one step. So long as the wiper engages grounded bank contacts, the MM will operate as a buzzer to advance the wipers step-by-step in search of an ungrounded bank contact.

The rotary action is fast (50 to 60 steps per second) and the stopping is positive. The stepping is reasonably smooth, although there is no toggle device to insure complete stroke of the armature. The "advance upon de-energization" feature has many advantages in circuit design, and is said to provide reliable operation over a greater range of operating voltages, impulse speed and ratios, than does direct drive. The above is commonly used in connection with the "homing" type of rotary line switch.

301 (b) Switch Advances Upon Energization of Motor Magnet: The conventions of Fig. 2 indicate a rotary

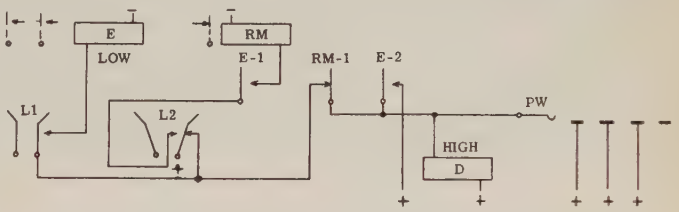



Fig.2 - Strowger Selector Searching For Absence Of Ground.

magnet RM about to advance a private wiper PW across an indicated level of private or control bank contacts. Low resistance relay E has two pairs of make contacts and RM has one pair of break contacts. Locking key L1 is shown in its normal position, but take care to note that locking key L2 is shown in its operated position.

This is a "detached contact" circuit diagram, and, while the springs are shown dotted in association with their respective relay, they are also shown "detached" in locations which make for simple circuit analization. Negative battery is always at the top of the figure, and the circuit of each relay progresses downward and to the right until it is completed at the bottom of the figure. Lever springs always move to the right to break a "break contact", or to make a "make contact."

We first operate L1 to close the circuit of E by way of make contacts on operated L2. Relay E energizes and locks itself up by way of RM-1 and E-2.

We next restore L2 to close the circuit of RM by way of E-1. Rotary magnet RM energizes to advance PW into engagement with the first bank contact and opens the locking circuit of E at RM-1. Relay E will restore (its operating circuit was opened when L2 was

restored), and open the circuit of RM at E-1. Rotary magnet RM also restores.

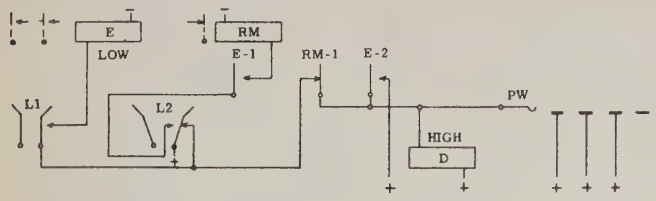



Fig. 2 - Strowger Selector Searching For Absence of Ground. (Repeated)

Ground on the first bank contact shunts out D and, when RM restores, again completes the circuit to E by way of RM-1 and L1. Relay E again energizes to complete the circuit of RM. Rotary magnet RM will again energize to advance PW one step, and open the circuit of E.

Thus it will be seen that relay D will remain shunted out so long as the private wiper engages grounded private bank contacts. The rotary magnet and relay E will continue to operate alternately, and as a result the wiper will be advanced step-by-step until an un-grounded contact is reached. The private wiper PW does not have an extended tip, as did the rotary switch wiper shown in Fig. 1, here the bridging effect is accomplished by having "wide" contacts in the private bank.

When PW reaches an un-grounded contact there will be no ground to shunt out relay D, however, a circuit will be closed through relay D via RM-1 and L1 to E . Relay E will not energize in series with the high resistance of D and the rotation will cease.

This is the "automatic rotary" and "stopping" circuit of the original Powell selector. Eventually the reader will recognize L1 as being the off-normal springs, L2 as springs on the series relay, and relay D as the switching relay of a Strowger selector. This circuit has a stepping speed of between 25 and 30 steps per second and is absolutely reliable.

302 Battery Searching: The conventions of Fig. 3 indicate a rotary magnet RM about to advance a pri-

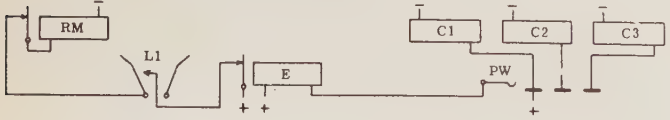



Fig. 3 - Strowger Selector Searching For Presence Of Battery.

vate wiper PW across an indicated level of private bank contacts. Note that locking key L1 is shown in its operated position.

We first restore L1 to close the circuit of RM by way of its own break contacts, L1 and break contacts on E. Rotary magnet RM energizes to advance PW into engagement with the first bank contact and opens its own circuit.

Ground on the first bank contact will shunt E, and the buzzer action of RM will continue. The second bank contact is neutral, because of the circuit failure just below C2, and can have no effect upon E. Wiper PW upon reaching the third bank contact, will complet the circuit of E by way of C3, whereupon E will ener gize in series with C3 quickly enough to stop th rotation by opening the RM circuit.

This is a typical "automatic rotary" and "stopping" circuit of a battery searching selector. Eventuall the reader will recognize L1 as being springs on th series relay, and C1, C2 and C3 as being relay C i the switches of the next rank.

302 (a) The conventions of Fig. 4 indicate a rotary magnet RM about to advance a private wiper PW acros

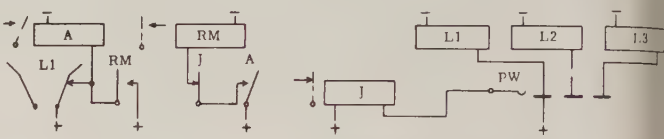



Fig. 4 - Strowger Finder Rotating In Search Of Battery.

an indicated level of private bank contacts. Note tha L1 is shown in its operated position, as is relay A.

We first restore locking key L1 to open the circuit of A, which restores to close the circuit of RM by way of break contacts on J and on A. Rotary magnet RM energizes to advance PW into engagement with the first bank contact and closes the circuit of A. Relay A energizes to open the circuit of RM, and, thereafter, RM and A continue to operate alternately to advance PW across the level until the first stopping point is reached. Nothing will happen on steps one and two but, when the third contact is reached, relay J will energize in series with L3 and open the circuit of RM.

This is an application of battery "stopping" to an automatic rotary circuit in which the rotary magnet and relay A play tag. This circuit has a stepping speed of between 25 and 30 steps per second, and will eventualy be recognized as the rotary circuit of a line finder. Rotary magnet RM is in the finder, while relays A and J are in the finder control group. Relays L1, L2 and L3 represent line relays accessible to the finder.

302 (b) In Fig. 5 is shown another of the many battery searching schemes, here the conventions indicate a rotary magnet RM about to advance a private wiper PW across an indicated level of private bank contacts.




Fig. 5 - Strowger Finder Rotating In Search Of Battery (Second Illustration)

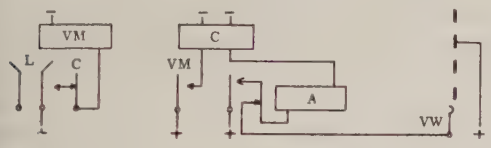
We first operate locking key L1 to close the circuit of RM by way of break contacts on C. Rotary magnet RM energizes to advance PW into engagement with the

bank contact and closes the left hand winding of Relay C energizes to open the circuit of RM, and eafter, RM and C continue to operate alternately dvance PW across the level until the first stop-point is reached. Nothing will happen on steps nd two, but, when the third contact is reached, a uit is established through the right hand aiding ing of C. Therefore relay C will remain ener-i even though its left hand winding is opened by thus the rotation ceases.

e are many more of these circuits, but the ex-es given are fairly illustrative of the art.

Searching for Ground: The conventions of Fig. 6 ate a vertical magnet VM about to raise a vertical r VW into engagement with an indicated row of cal bank contacts.

rst operate locking key L to close the circuit of y way of break contacts on C. Vertical magnet




ig. 6 - Strowger Finder Stepping Vertically In Search Of Ground.

nergizes to raise VW into engagement with the bank contact and closes the circuit of the left l winding of C. Relay C energizes to open the it of VM and, thereafter, VM and C continue to te alternately to raise VW over the vertical contacts until a marked contact is reached. The contact in the figure has been marked by ground when this contact is reached, a circuit is closed gh the right hand winding of C by way of A and contact thereon. Relay A energizes and locks and relay C to ground by way of its own "make-e-break" springs, thus the vertical movement s.

"All Relay" Searching Circuit: Anything that e done by stepping switches can also be done lays, but in all probability the cost will be high-d the results not so satisfactory. Obergfell ably the best of the second generation of mech-l designers) was fond of saying, "Some things e done best mechanically, some things can be best electrically, but most things can be best plished by a combination of the two."

onventions of Fig. 7 indicate an "all relay" hing circuit. A relay C is provided for each f the circuit, the marking is secured by battery gh relay B, and the stopping accomplished by y A. The depressing of locking key L1 closes a it down through the chain to the first C relay, energizes and locks up by way of its "X" first) contacts, and extends the start to the d C relay.

pparent that relays C will energize one after her, much as a row of dominos, standing on end, will fall down in sequence when the first is toppled over. The speed of searching is dependent on the

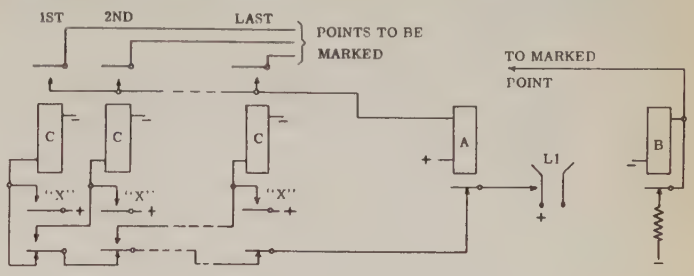



Fig. 7 - "All Relay" Searching Circuit.

characteristics of the relay used, and may be anything desired, so long as relay A can operate quicker than the "X" springs of the next searching relay. Note the non-inductive shunt normally around relay B.

304 (a) The "all relay" searching circuit shown in Fig. 7a is that of a distributor serving a plurality of finder switches. The distributor consists of an FD relay for each finder in the group and a pair of common relays RS1 and RS2.

As shown in the figure, the distributor has preselected the first finder and ground on the RS2 lead holds operated relay RS1 and the first FD relay. When the first finder switches the calling line through to its associated selector, ground will be placed on the G lead to cause the distributor to select the next idle finder relay group and eventually closes the circuit of the second FD relay by way of make springs on the first FD relay.

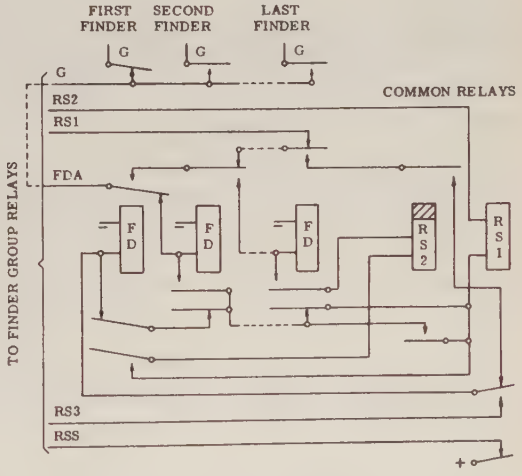



Fig. 7a - "All Relay" Distributor Circuit

(A) Selection of Next Idle Finder: Relay FD (second) operates; (1) closes its own locking circuit in series with relay RS1; (2) prepares the G lead to the second finder; (3) prepares the start circuit (not shown) to the second finder; (4) prepares the circuit to the next FD relay of the distributor; and (5) opens the holding circuit of the preceding FD relay.

Relay FD (first) releases; (1) opens the G lead; (2) opens the operating circuit of relay FD (second); (3) opens the start lead to the first finder (not shown);

(4) prepares the circuit to relay FD (third); (5) opens further its locking circuit, and (6) prepares a circuit to relay RS2.

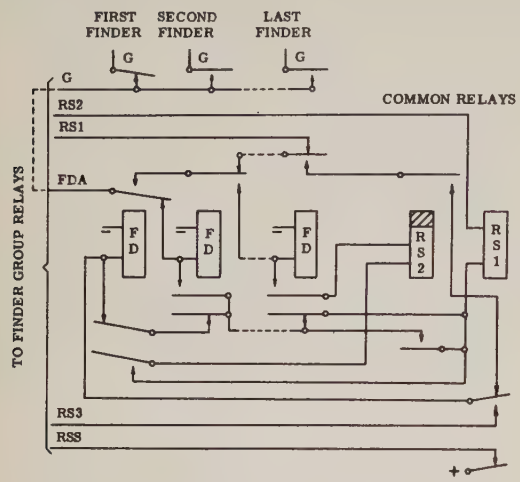



Fig. 7a - "All Relay" Distributer Circuit (Repeated)

(B) Next Finder Busy: If the second finder had been busy, ground would have been encountered on the associated G lead. Therefore the first FD relay, upon releasing, would have completed a circuit to the third FD relay from ground on the G lead to the second FD relay. The third FD relay will now operate and allot the call to the third finder.

If the third finder were busy, the search for an idle finder would continue in a manner similar to that described above.

(C) Distributor Operation When Last FD Relay Operates; When the next to the last finder becomes busy, the circuit is closed to the last FD relay, whereupon:

Relay FD (last) operates; (1) closes its own locking circuit in series with relays RS1 and RS2; (2) prepares the G and start leads to the last finder; (3) prepares the circuit to relay FD (first); and (4) opens the circuit to the next to the last FD relay, causing its release.

Relay RS2 operates; (1) prepares the operating circuit to relay FD (first); and, (2) prepares the locking circuit to relay FD (first).

When another call is initiated, the last finder finds the line, switches through, and places ground on the G lead to operate the FD (first) relay.

Relay FD (first) operates; (1) closes its own locking circuit in series with relay RS1; (2) prepares the first finder for the next call; (3) opens its operating circuit; (4) prepares a circuit to the FD (second) relay; and, (5) opens the circuit to relays FD (last) and RS2.

Relay FD (last) releases and closes a multiple circuit to relay RS1.

Relay RS2 releases; (1) opens the operating circ to relay FD (first) and, (2) opens a multiple circ to relay RS1.

305 Driving Circuits; Driving circuits are essenti the same whether they actuate (1) a rotary swit (2) a minor switch or (3) a Strowger switch.

305 (a) All driven switches are actuated by puls which is a very confusing term, as the reader soon see. In discussing pulses two things must considered, first their generation and, second, t number of pulses in the group.

The telephone dial is a good place to start our di cussion for it combines both a generating and gro ing means, and is, as the old patent claim stat "a device to send a number of impulses correspo ing to the selected holds." The dial we will fir discuss is actually the old dial, and not the dial u in modern two wire circuits.

When an open circuit or "Tele-Chec" dial is mov off normal a pair of "shunt springs" are forced i engagement and so remain until the dial returns normal. As the dial returns to normal positio pair of "make" impulse springs are actuated a nu ber of times corresponding to the digit called.

306 Temporator Driving Circuit: The word "Tel Chec" is descriptive of an Ushers Call system us in theaters, and the open circuit dial used therein h come to be called by the same name. The Temp rator system also had to do with the displaying visual information and utalized a rotary switch i very interesting manner.

Let us assume that the number 89 is called on t tele-chec dial shown in Fig. 8 (perhaps to indicate

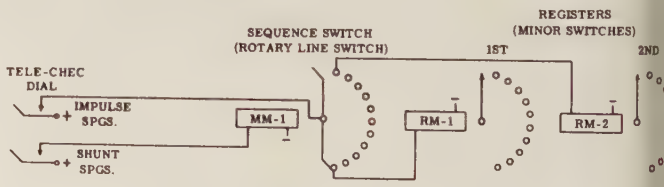



Fig. 8 - "Tele-Chec" Dial Driving Rotary Switch.

vacant seats, or that linotype machine #89 needs service man). When the dial is first moved off no mal, a circuit is closed to MM-1 of the sequen switch by way of the shunt springs. Motor magn MM-1 now energizes, but without effect, since t rotary switch advances only on de-energization its motor magnet.

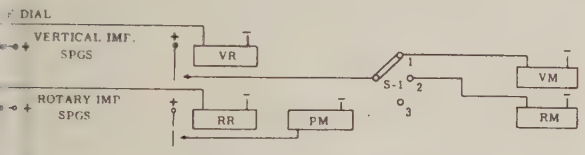
As the dial returns to normal, after dialing of t digit 8, eight impulses of current will pass from t impulse springs by way of the sequence switch, wip and eleventh bank contact, to RM-1 of the first regi ter. As a result of the foregoing, the first registe will advance its wiper eight steps. The circuit MM-1 will be opened when the dial reaches its no mal position, and the sequence switch will advan its wiper into engagement with bank contact 1.

the dial is next moved off normal, a circuit is closed to MM-1, but without effect. As the dial rns to normal, after the dialing of the second nine impulses of current will pass from the se springs by way of the sequence switch wiper, irst bank contact, to RM-2. As a result of the ping, the second register will advance its wiper steps. The circuit of MM-1 will again be opened the dial reaches its normal position, and the se- e switch will advance its wipers into engagement ank contact 2.

s been said before, the sequence switch makes simple circuit operation.

3-Wire Driving Circuit: The old 3-wire dial was n open circuit dial and, while returning to nor- actuated two sets of impulse springs. The ver- springs were actuated a number of times corre- ing to the digit dialed and, finally, the rotary se springs were actuated once.

s assume that the number 89 is dialed on the e dial as shown in Fig. 9. As the dial returns




ig. 9 - "3-Wire" Dial Driving "3-Wire" Strowger Connector.

mal, after the dialing of the digit 8, eight im- s of current will pass to the vertical relay VR. VR will energize eight times and, at each ener- on, will close the circuit of vertical magnet VM ay of side switch wiper S-1 in first position. efore the dial reaches normal, a single impulse rrent will pass to the rotary relay RR. Relay ill energize momentarily and close the circuit vate magnet PM. Private magnet PM will ener- and de-energize to cause side switch wiper S-1 ss to second position. For the mechanics of this see Fig. 39 Sec. 335 (c). For further discus- of the side switch see AT (Clapham) 8-20.

e dial returns to normal, after the dialing of the 9, nine impulses will be repeated by VR and cted to rotary magnet RM by way of the side h wiper S-1 in second position. Just before the reaches normal, a single rotary impulse will be ted by RR to PM, which will energize momen- to advance S-1 to third position.

that further rotation of the Strowger switch is ssible because the circuit of RM is now open at

2-Wire Driving Circuit: The goal of 2-wire ation was the removal of pulsing ground at the subscribers station, therefore the only control possible was the opening and closing of the sub- scribers loop. The conventions of Fig. 10 indicate

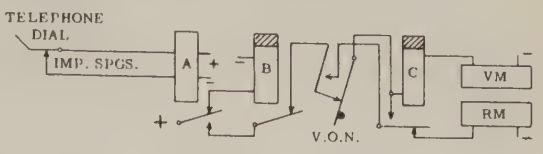



Fig. 10 - "2-Wire" Dial Driving Strowger Connector.

a double wound line relay A energized over a loop including the impulsing springs of a closed circuit dial. Slow to release relay B is shown energized from make contacts on A. The vertical off-normal springs VON are shown in the position which they assume when the shaft of the Strowger switch is at normal.

We will now assume that the number 89 is dialed. As the dial returns to normal, following the dialing of the digit 8, the circuit of line relay A is momentarily opened eight times. Each time the armature of relay A falls back it opens the circuit of relay B. Relay B does not de-energize, however, on account of its being a slow to release relay. The first time the armature of relay A falls back, a circuit is closed by way of make contacts on B, break contacts of VON, through relay C and thence to vertical magnet VM. The current flowing in this circuit will cause relay C and the vertical magnet to operate.

Relay C, being a slow to release relay, will maintain its armature in an operated position for the fraction of a second. The next time the armature of relay A falls back, the same circuit is closed, except that since the shaft has already been raised one step the circuit will pass through the make contacts of VON, and the make contact of relay C. Shortly after the last impulse of current has passed through the relay C, it will de-energize and cannot again become energized on account of the open circuit at the off-normal springs.

As the dial returns to normal, after the dialing of the digit 9, nine impulses will be repeated by A and directed to the rotary magnet RM by way of make contacts on B, make contacts on VON and break contacts on C. The current flowing in this circuit will cause the rotary magnet to energize nine times and thereby rotate the shaft and wipers into engagement with the bank contacts associated with telephone number 89.

Further rotation of this specific Strowger switch will occur if the dial is again operated.

309 "All Relay" Driving Circuits: "Counting relays" can be made to do any thing that a stepping switch can do, if you don't care about cost and complexity. There are literaly hundreds of different counting circuits, some of them simple and some "Reflexed" to the point where it is questionable if even their designers know why they work.

310 Two Relays Per Step: A most simple and quite reliable counting circuit is shown in Fig. 11. At the

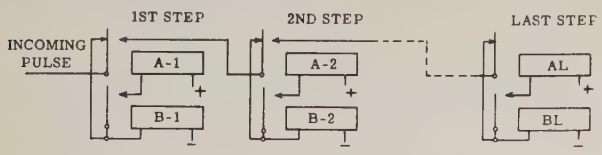



Fig. 11 - Counting Relays, Two Relays Per Step.

next impulse, relay B-1 will energize by way of break contacts on A-1, and at the end of the pulse relay A-1 will energize in series with B-1 and transfer the pulsing circuit to the next step.

310 (a) The circuit of Fig. 12 is more complicated, but is to be preferred to the series relay operation of Fig. 11. At the first pulse, A will operate to close

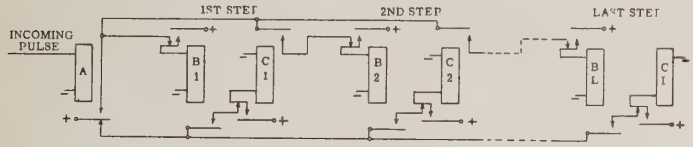



Fig. 12 - Counting Relays, Two Relays Per Step (Second Illustration).

the circuit of B-1, the latter relay then locks up and prepares a circuit to C-1. At the end of the pulse A will de-energize and close the circuit of C-1 by way of make contacts on B-1, whereupon relay C-1 will energize and transfer the pulsing circuit to the next step.

311 One Relay Per Step: Note that relay B in Fig. 13 is not a "two step" relay. The two windings of B

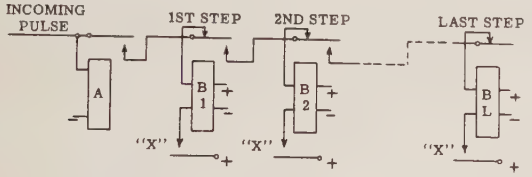



Fig. 13 - Counting Relays, One Relay Per Step.

assist, and the "X" contacts make before the break contacts break. The only critical requirement is that relay A must fall away while relay B transfers.

At the next pulse, relay A will energize and extend the pulsing circuit to relay B-1, but without effect. At the end of the pulse, the upper winding of relay B-1 will energize in series with relay A (the introduction of the B-1 impedance into the circuit will start A on the downward path). The "X" contacts on B-1 make first, and the lower winding causes the relay to energize and transfer the pulsing circuit to the next step. Relay A is already pretty sick, and it is no particular trick to make it fall away while B-1 is transferring. This is a very fast and reliable counting relay circuit.

311 (a) As shown in the figures above, all the counting relays have remained energized, which causes undue battery consumption and introduces circuit complications. In Fig. 14 is shown a circuit in w the relay behind is cut off at each step.

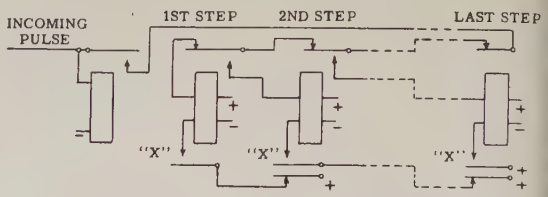



Fig. 14 - Counting Relays, Relay Behind Cut Off At Each Step.

311 (b) It is sometimes desirable to have an end counting chain, as shown in Fig. 15.

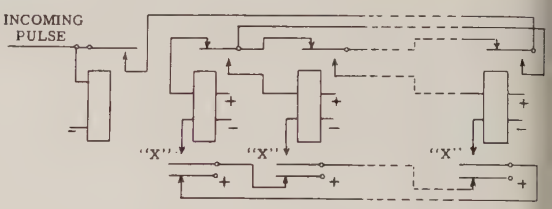



Fig. 15 - Counting Relays, Arranged in Endless Chain.

312 Restoring Circuits: Every driving circuit m have associated with it a restoring circuit, which turns the mechanism to its normal position. Wh the distances are short, and the cost of added c ductors not unduly burdensome, this is best done the use of a release conductor.

In the case of rotary switches it is customary to p vide a private level (see Sec. 301 (a), Fig. 1) multiple the release conductor to all contacts ther except that of the "home" position. Ground placed the release conductor by way of a non-locking p key will then cause the rotary switch to resto Some rotary switches are equipped with off-norm release springs.

A further refinement would be to interpose a relea relay, thus preventing the danger of a short relea pulse. The release conductor now terminates in winding of a double wound relay which, upon ene gization, (1) grounds the private bank multiple (2) locks its second winding to the private wiper, would be good skull practice for the reader to figu out why a single wound relay could not be used this circuit.

312 (a) The Strowger Release Circuit: In telepho practice conductors are at a premium, and the r lease feature had to be superimposed on the drivi circuit.

In 3-wire days the release was accomplished simultaneously grounding both line conductors. Th was a switch hook function, governor controlle thereby obviating the possibility of a short relea pulse. In 2-wire practice, see Fig. 16, the relea magnet is actuated by the de-energization of relea relay B. The restoration of the receiver to t switch hook will open the circuit of line relay which will de-energize to open the circuit of relay A fraction of a second later release relay B will d energize and close the release magnet circuit by w of make VON springs and break springs on relays

.. The release magnet will operate to remove ouble dog, following which its own circuit will be

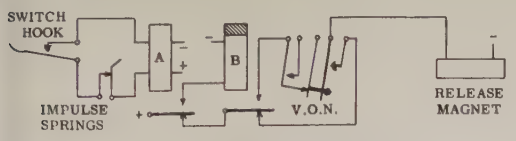



Fig. 16 - "2-Wire" Release Circuit.

ed at the VON spring when the switch shaft es normal. For article on the development of rowger release, see AT (Martin) 1-19.

mpulse Generators: In Sec. 305 (a) mention nade of the fact that the telephone dial combined he generating and the grouping of pulses. e now to discuss pulse generation, particularly (1) speed and (2) pulse ratio. But first a word just what is meant by the word pulse.

ce in Wonderland the Duchess said "words mean what I want them to mean." And that is just what they do in Strowger literature.

ar as this section is concerned, let the word e" mean the slug of current which actuates the magnet of a driven switch. Any driven switch function best if the incoming pulses are of a acter best adapted to actuate that particular anism.

) Speed: In general, the lighter the mechanism gher the permissable speed. Strowger switches te best when the driving speed is approximately eps per second.

) Pulse Ratio: Pulse ratio means the ratio een the length of time the circuit is closed and otal length of the complete cycle. For best ation of Strowger driven switches the pulse to nagnet should be 61 1/2% of the complete cycle. longer "make" is necessary to assure that the magnet receives the amount of power needed mplete operation. See Sec. 141 for discussion t and heavy impulses.

nat the reader has the above well in mind, we proceed to confuse him by referring to Fig. 10. that the slug of current to the magnets is de- ined by the "break" of the impulse springs, ack contact of A relay). Therefore the dial is monly spoken of as having a 38 1/2% make. is perfectly true - if you can figure it out.

) The ideal way of generating impulses would means of cams and reduction gear, driven by a oneous motor, but oftentimes some cheaper must be adopted. Any self-interrupting motor et is in effect an impulse generator, but, as d out in Sec. 210 (b), the impulses are very to be ragged.

h uniform pulses at ten per second are some- ard to produce electrically, it is equally hard to produce slow pulses. Both are required in telephone and remote control applications, and the following illustrative circuits should be of interest.

314 In Fig. 17 is shown an impulse generator which uses a large capacity electrolytic condenser to produce delays on both operation and release. Ground from the locking start key L passes through the limiting resistance R and then divides, part going through the upper winding while the rest goes through the electrolytic condenser and lower winding. Since the windings oppose, the relay will not operate until the

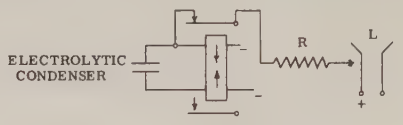



Fig. 17 - Low Speed Impulse Generator.

condenser approaches full charge and current stops flowing into it. The relay then operates from the current flowing through the upper winding, and opens its operating circuit.

The condenser now discharges, the current flowing through both windings in the same direction, thus holding the relay operated until the condenser approaches the discharged condition, whereupon the relay releases. The cycle is again repeated.

315 In Fig. 18 is shown a very excellent impulse generator that is generally attributed to John Erickson.

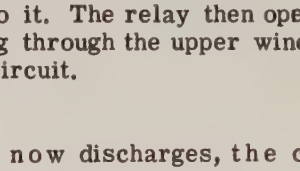



Fig. 18 - Medium Speed Impulse Generator.

It does not look as if it would work, but it does, very beautifully and uniformly. It will give a minimum of about 60 I.P.M.

316 In Fig. 19 is shown an impulse generator which produces pulses at dial ratio and speed (assuming

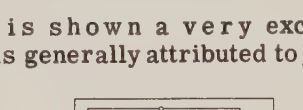



Fig. 19 - High Speed Impulse Generator.

that proper relays have been selected). Ground from the locking key L operates relay A by way of break springs on relay B. Relay A, upon energizing, locks itself to ground (to insure that a complete cycle will be completed even though key L be quickly restored) and closes the circuit of C. Relay C energizes and closes the circuit of B. Relay B operates to open the circuit of A, which restores, opening the circuit of C, which also restores, completing the cycle.

The above operations will continue so long as key L remains operated. The pulse producing springs are mounted on relay C.

317 Delayed Operation: The principle underlying delayed operation was discovered accidently, when it was found that certain relays, which tended to be sluggish in operation and release, had a number of short-circuited turns within their coils. These short-circuited turns retarded (1) the building up of the magnetic flux in the coil when the circuit was closed and, (2) they retarded the dying away of the flux when the circuit was opened.

Short circuiting of portions of a relay winding is sometimes employed to secure delayed relay operation (see Slugless Pulsing, Sec. 167). However the same result is more generally accomplished by simply replacing a part of the coil winding with (1) a slug (a collar of solid copper having the same outside diameter as the winding) or, (2) a sleeve (a tube of copper over which the winding is placed). For further discussion of slow acting relays see, AT (Clapham) 3-20, and STJ (Fowler) 6-36.

318 Operate Time Delay: An operating delay, up to about one tenth of a second, can be secured by placing a slug on the armature end of the core.

318 (a) An operating delay, up to about 2 seconds, can be secured by the weighted spring arrangements shown in Fig. 20.

When relay A is energized, its armature strikes the weighted spring, which rebounds and oscillates against

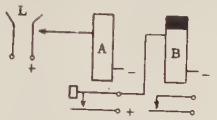



Fig. 20 - Weighted Spring Relay.

the armature spring a number of times, gradually slowing down until it finally comes to rest. At each oscillation, it sends increasingly longer pulses to slow to operate relay B, which, however, does not operate until the length of the pulse exceeds the operate time of that relay.

318 (b) In Fig. 21 is shown an adjustable delay circuit. This circuit has a variable series resistor

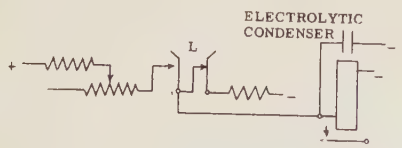



Fig. 21 - Adjustable Delay Circuit.

which restricts the current flowing to the relay and condenser upon the operation of locking key L. The condenser shunts the relay during charging time, and thus delays the relay from operating until the condenser approaches full charge. At that time the relay operates and closes the delay circuit.

The condenser is shunted when key L is restored, in order that the relay may de-energize rather promptly. If the shunt path were not provided, the condenser would keep discharging into the relay and hold it operated for some time. See Sec. 314.

319 Release Time Delay: A release time delay, up to about .350 seconds, can be secured by placing a slug on the heel end of the coil core.

319 (a) A release delay, up to about 15 seconds, can be secured by the use of the vibrating reed relay shown in Fig. 22. Relay A, upon fully operating, closes the

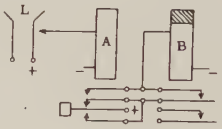



Fig. 22 - Vibrating Reed Relay.

circuit of B, which locks up to the vibrating contact of A.

When the circuit of A is opened, the weighted spring vibrates between its adjacent springs and sends progressively shorter pulses to relay B. Being slow to release, relay B does not de-energize until the length of the pulse becomes less than its release time. Relay B cannot again operate, due to a slight vibration of A, because its locking circuit has been opened.

320 For a combined operate and release time delay, see Sec. 314, Fig. 17.

321 Pulse Repeater Circuits: In telephone and telegraph practice the character of a pulse may become so attenuated by line conditions that the pulse reaching the distant end is incapable of reliably operating the equipment. Some means must then be used to restore or regenerate the character of the received pulse.

In certain other applications it may be found desirable to shorten or lengthen a single pulse.

321 (a) Pulse Shortening: Sometimes the incoming pulse is of longer duration than it need be, then the "spit" circuit of Fig. 23 can be used to advantage.

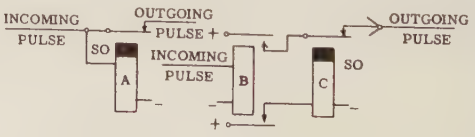



Fig. 23 - Pulse Shortening Circuit.

The length of the outgoing pulse is determined by the operate time of relay A.

Relays B and C are so arranged that the common will not feed back on the individual circuits.

321 (b) Pulse Stretching: The non-inductive winding of relay A, Fig. 24, acts as a slight pulse stretcher and is commonly used to stretch the pulse from a Tele-Chec dial.

release pulses originate in a manually operated it is often advisable to use the pulse stretcher n at B and C. Relay B, energizing on the slight-

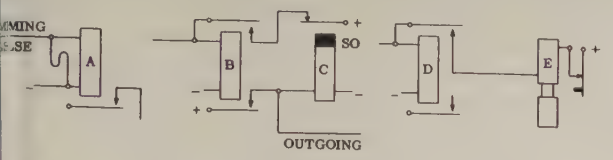



Fig. 24 - Pulse Stretching Circuit.

coming pulse, closes the circuit of the slow to te relay C and locks itself to break contacts on relay. The outgoing pulse in no event can be ter than the operate time of relay C, about .25 ds.

combination of relay D and oil dash pot E will h the minimum pulse to a maximum of about 3 es.

) Alternate Open and Close Combinations: It is times desirable to have a relay combination which nergize on the first incoming pulse, lock up, main locked up until the next pulse on the same s received. This scheme is of particular value requency changer, each pair of relays cutting eed of the prime mover in half.

hart in Fig. 25 is the circuit explanation, dotted indicate energization of windings, while solid

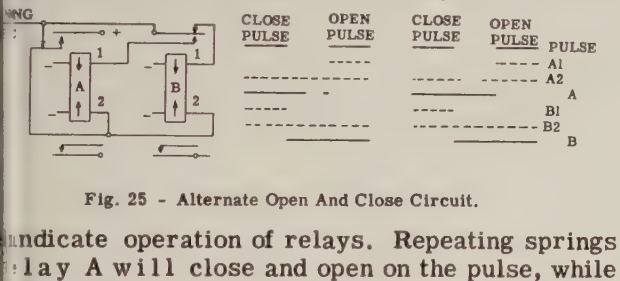



Fig. 25 - Alternate Open And Close Circuit.

ndicate operation of relays. Repeating springs lay A will close and open on the pulse, while ing springs on relay B will close and open after lse.

ock Pulsing Circuits: There are as many lock g circuits as there are designers that have d on the problem. In all cases the idea is to r standard pulses to the motor magnet even the pulses received from the line relay may be light or heavy.

cal circuit is shown in Fig. 26. When the line as closed, relay A operated to close the cir- of L by way of break contacts on B. Relay L through resistance R-1 and closed the circuit Relay B locked up by way of make contacts on med the operating circuit of L, prepared the g circuit to motor magnet MM, and prepared cuit whereby A can pulse ground to the line h resistance R-2.

Light Pulses: Relay C and motor magnet e assured of an adequate pulse if A falls back long enough for L to open its locking circuit. L opens its locking circuit, it cannot re-operate until A has re-operated and the motor magnet has completely energized. When L re-operates, it locks up and opens the magnet circuit.

Note that it is not necessary for A to complete its break contact in order for the magnet to be stepped. Since L is held through resistance, it is very quick to release. The make-before-break springs on L are to reduce contact chatter.

Secondary oscillations of the line may cause A to operate momentarily after its initial release, but

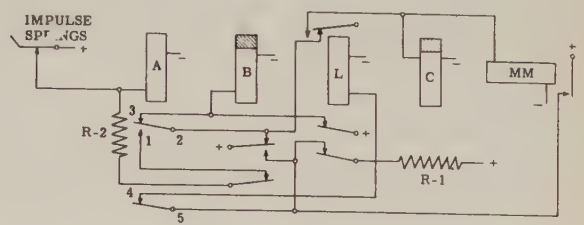



Fig. 26 - Lock Pulse Circuit.

this will not effect the magnet because the extra kick of A will have passed before the magnet can ground the reset circuit of L. This is very important, since A must be an exceedingly fast relay, and consequently responds to line oscillations which would not influence the ordinary line relay.

322 (b) Heavy Pulses: When the calling dial is located at the end of a long line having high insulation resistance, A tends to fall back promptly and to re-operate slowly. This makes for heavy pulses to the magnet.

To offset this tendency toward heavy pulses, relay A closes a circuit through its own back contact and resistance R-2 to the line. In effect an artificial lead is thus established.

It should be noted that the artificial lead circuit is not completed until A has completely restored, so it cannot retard the release of A. The resistance R-2 is so high that A cannot operate on the leak current, but A will get a pre-saturation which will assist it to operate more promptly when the dial springs again close.

322 (c) Dial Speed Range: This pulse compensating circuit is designed to meet the requirements of lines which cause A to produce very short pulses at high dial speed (12 I.P.S.). At the lower dial speeds, extreme line conditions do not effect relay A to the same degree. In other words, the pulse compensator accepts pulses from worse lines as the dial speed decreases. For further discussion of dial speed see AT (Andres) 3-23.

323 Pulse Cut-In Circuits: It is sometimes necessary to guard against the possibility of connecting a circuit to a pulsing conductor in the middle of a pulse. If the locking key L of Fig. 27 is depressed during a

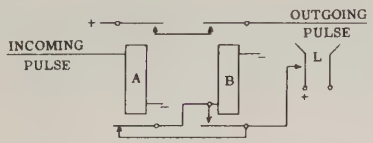



Fig. 27 - Pulse Cut-In Circuit.

pulse, relay B cannot operate because of the break contacts on A. At the end of the pulse, B will operate and lock up to key L, pulses received thereafter will be repeated to the outgoing circuit.

324 Interlocking Relays: Relays connected to the bank of a Strowger switch are often interlocked to insure that they may be operated only in a prescribed sequence. Relay A, Fig. 28, will remain energized only so long as the wiper engages bank contact 51.

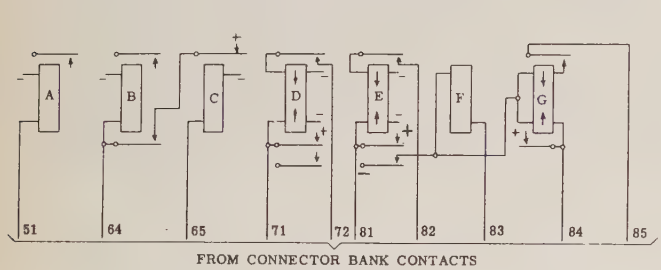



Fig. 28 - Interlocking Circuit.

Relay B will energize from bank contact 64, and will lock up to break contacts on relay C. A subsequent dialing of the digits 65 will energize relay C, thus restoring relay B.

The lower winding of relay D will energize from bank contact 71 to lock itself up and prepare the circuit of its upper winding. A subsequent dialing of the digits 72 will energize the upper winding and knock down the relay.

Relay E functions in a manner similar to relay D. Relays F and G cannot be energized until after relay E has locked up.

324 (a) Remote Control Circuit: In Fig. 29 is shown a simple circuit which will place ground on a se-

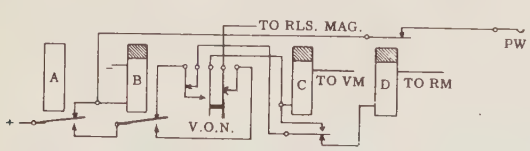



Fig. 29 - Remote Control Circuit.

lected bank contact. The contacts of the associated control bank must be non-bridging. Note that ground is placed on the wiper PW after the second digit is dialed, that wiper PW is open during rotation and during release, and that the rotary magnet is not cut off.

325 Lock Out Circuits: A lock out scheme permi one of a plurality of originating circuits to seize common circuit and lock out the other originatin circuits. In Fig. 30, both the test conductor and th

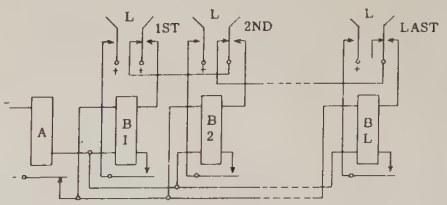



Fig. 30 - Lock Out Circuit.

lock out conductor are multipled through all positions There are countless variations of this circuit.

326 Counting and Totalizing: It is true that any re mote control application can be served by relays a well as stepping switches, but usually at a higher cos and with increased complexity. In counting and total izing applications where ultra high speed and heav duty is required, as in the race track "Totalisator" (A.E.Co. Bul. 1673), the use of "all relay" collector and adding machines are imperative. In the grea majority of cases stepping switches will prove to b very satisfactory adding machines.

327 Counting: Generally, stepping switches are use for counting because of the nature of the switch itself After receiving an impulse from a contactor, th switch steps once. If the contactor is controlled b the objects being counted, then the number of steps the switch takes is an accurate count of the numbe of objects passing by.

A "units" register can be wired to "carry over" into a tens register on the tenth pulse. An eleve point rotary switch is usually used for this purpose. One pair of make contacts on the units pulsing relay drives the units motor magnet, while a second set of make contacts is wired to a line wiper of the units switch. The ninth bank contact accessible to the afore mentioned wiper leads to a tens pulsing relay. One pair of make contacts on the tens pulsing relay drives the tens pulsing magnet, while a second set of make contacts is wired to a line wiper of the tens switch. The ninth bank contact accessible to the last mentioned wiper leads to a hundreds pulsing relay, etc.

Each register is equipped with a private bank, the first 9 contacts of which are in multiple and wired to a pair of make contacts on the restoring relay. The tenth contact in each private bank is permanently wired to ground, thus the switch becomes in effect a "ten-point" switch.

The contacts of a third level on each switch can be wired to display lamps if desired. A fourth level may be used for an alarm or machine stop.

328 Totalizing: The carrying over from units to tens, from tens to hundreds, etc., should not be thought of as totalizing. A totalizer picks up (collects) mark-

on individual circuits and passes them to a cum-ve register.

a very simple totalizer, visualize a self-interrup-rotary switch continually scanning its bank. At step a pulse is, or is not, sent to the cumulative ister, depending upon whether or not the associ-individual circuit is marked. This simple me should not be used where two consecutive kings on any one circuit are likely to occur with-e time required to cumulate simultaneous mark-on all circuits.

In And Out Circuits: In and out circuits are n, the following illustrations may be of interest. crossing signal control shown in Fig. 31 is one

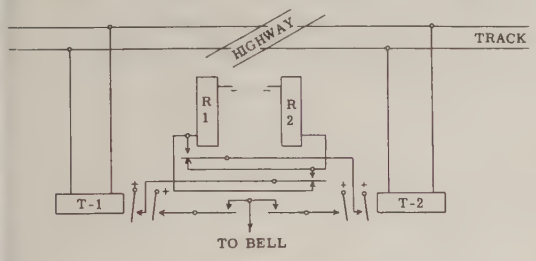



Fig. 31 - Crossing Control Circuit.

e simplest of the in and out circuits. The shunt-f either track relay will bring in the bell, which continue to sound until both track relays are n at normal (energized).

(a) Visualize two single level rotary switches their banks in straight multiple, and an alarm machine stop) circuit wired through the two rs. Now advance the "in" switch one step to k the alarm circuit, the alarm can not again sound the "in" switch has gained a complete revolution 25 or 50 steps) on the "out" switch. As used in 'Power Demand Limitator", the "in" switch driven by pulses from a kilo-watt-hour meter he "out" switch was driven by time pulses from ock. If the "in" switch gained sufficiently, the nine stop circuit caused a reduction in voltage to ttery of electric furnaces, thereby insuring that a etermined max-demand would not be exceeded.

Wheels Counted: The circuit shown in Fig. 32 mits "in" counting only, the movement must be

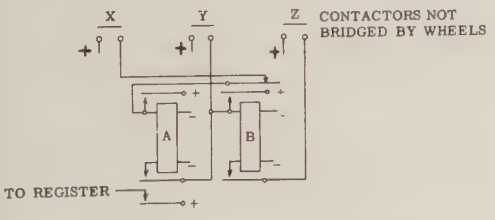



Fig. 32 - Wheel Counting Circuit.

pleted in direction started, but need not be con-ous. The contactors are not bridged by wheels.

Direction Established: The circuit shown in 33 establishes direction and counts wheels. It can only be used when movement is continuous in direction started.

331 (a) The circuit shown in Fig. 34 establishes direction and counts wheels without limitation.

An analysis of the last three circuits may now be made. (1) Assume that a wheel depresses contactor

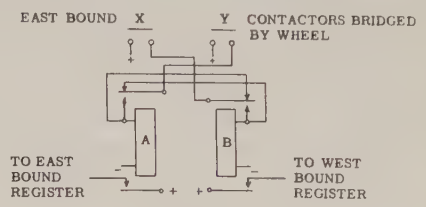



Fig. 33 - Direction Established And Wheels Counted (Limited Application).

"X" only. The associated register will be operated in Fig. 32 and Fig. 33, but not in Fig. 34. (2) Assume that a wheel depresses contactor "X" only, backs off, and again depresses contactor "X" only. The associated register will not be operated in Fig. 34, will be operated once in Fig. 32, and will be operated twice in Fig. 33. (3) Assume that a wheel depresses

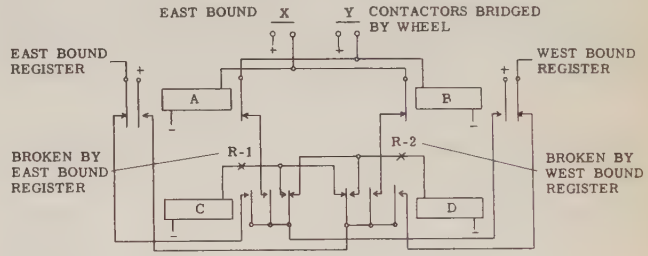



Fig. 34 - Direction Established And Wheels Counted Without Limitation.

contactors "X" and "Y" only. The associated register will be operated and released in Fig. 32 and Fig. 34, but will be operated and held in Fig. 33. (4) Assume that a wheel depresses contactor "X" and "Y" only, backs off, and again depresses contactor "X" only. No further registration will occur in Fig. 32 because relay B locked up and can only be released by contactor "Y". In Fig. 33 a second registration occurs when "X" is again depressed. In Fig. 34, the original movement caused an "East" registration, the reverse movement a "West" registration, and the final depression of "X" was without effect.

The circuit operation of Fig. 34 is rather complex and warrants detailed explanation. The depression of contactor "X" closes the circuit of A, which operates to close C by way of break contacts on D. The subsequent depression of contactor "Y" closes the circuit of B, which operates to close a locking circuit to C by way of make contacts thereon and break contacts R-1, and prepared a circuit to the "East' bound register by way of make springs on C and break springs on A.

When the "X" contactor restores, A will de-energize to open the operating circuit of C and to close the circuit of the "East" bound register. The "East"

bound register operates and opens the locking circuit of C at R-1. Relay C now restores and closes the circuit of D.

Relay D energizes but without effect at this time. If the movement is continuous, the opening of "Y" will cause the de-energization of B, and the subsequent de-energization of D, both without effect. But, if the movement is reversed, the closing of "X" will operate A to close the circuit of the "West" bound register by way of break contacts on D.

332 Alarm Circuits: The circuit shown in Fig. 35 utalizes a "two-step" relay to provide both a circuit

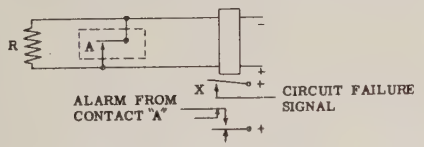



Fig. 35 - Alarm Circuit With "Circuit Failure" Signal.

failure signal and an alarm. The normal current flow operates only break springs "X".

The circuit shown in Fig. 36 provides a "come clear" signal in addition to the primary alarm. Relay A,

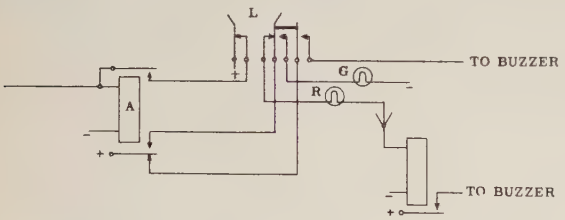



Fig. 36 - Alarm Circuit With "Come Clear" Signal.

upon energization, locks up to key L and brings in the red lamp R and the buzzer. Locking key L is then operated to unlock A and kill the red lamp and the buzzer. If A is still energized, the green lamp G will light. When the circuit "comes clear", relay A will de-energize to kill the green lamp and bring in the buzzer.

333. Non-Telephone Patents: The Circuit Kinks shown above are merely illustrative and space does not permit of a more complete discussion. Perhaps a few readers will desire to pursue the subject further and, for that reason, reference is made to the following Hershey Patents. The writer devoted some ten years to the application of Strowger principals in various non-telephone fields. Copies of the following patents may be obtained for ten cents each, by addressing the "Commissioner of Patents, Washington, D.C."

A - Electric Light and Power Industry:

1. Carrier Current Installations. (Such installations utilize power transmission lines over which the carrier current is transmitted from one power station to another): Patent No. 1,911,712, No. 2,275,146 and No. 2,275,147.
2. Power Demand Limitator. Patent No.1,942,42
3. Power Supervisor's Board. (An animated m which presents to the load dispatcher a co stant display of accurate information regar ing the position of switching devices and the connection in the system for the transmissi and distribution of electrical energy.) Pate No. 1,960,781, No. 1,986,972 and No. 2,056,72
4. Remote Control and Supervision. (One of plurality of switching devices in a remo station can be selectively operated by a di patcher in a central station, and the oper tion of any one of a plurality of devices i remote station will be indicated in a centr station.) Patent No. 1,795,650, No. 1,803,61 No. 1,814,385, No. 1,816,186, No. 1,888,2 No. 1,930,517, and No. 1,932,623.

B - Motion Picture Industry: (Control from sou film.) Patent No. 1,956,351.

C - Radio Broadcasting Industry:

1. Announcement Cut-In Circuit. Patent N 1,944,688.
2. Receiving Station Selection. Patent N 1,900,499.
3. S.O.S. Reception. (A receiving device whic may be used in conjunction with wireless r ceiving apparatus and which will respond and record only a predetermined signal, su as an S.O.S. distress call.) Patent N 1,968,078, and No. 2,040,691.

D - Railway Industry:

1. Car Counting. Patent No. 1,810,211.
2. Highway Crossing Protection. Patent N 1,824,207 and No. 2,231,671.
3. Interlocking Plants. Patent No. 1,960,78
4. Train Dispatching. Patent No. 1,882,0 No. 1,888,268, No. 1,888,985, No. 1,960,7 No. 2,008,910 and No. 2,047,631.

E - Miscellaneous:

1. Aircraft Position Indicator. Patent N 1,999,810.
2. Fire Alarm Systems. Patent No. 2,053,7 and No. 2,236,822.
3. Taxicab Dispatching. Patent No. 2,008,90
4. Tele-Chec Systems. (Display of informati at a remote point.) Patent No.1,832,11 No. 1,960,780, No. 2,052,018 and No. 2,330,35
5. Time Signals. Patent No. 1,924,402.

umerical List of Patents: The patents cited are here listed in numerical order. The date, wing the patent number, indicates the year in h the invention was made. A short description n of each patent.

795,650 (1927). This invention discloses a re-control system of the "On Call Visual Type", e position of the power switching devices are ly indicated only when the dispatcher originates

303,614 (1926). This invention relates to a re-control system, and discloses means to insure onous operation of the distributors.

310,211 (1928). This invention relates to a ing system in which objects passing a certain re automatically counted, and the count regis-n meters. The disclosure is made in connec-ith a railroad freight yard.

314,385 (1926). This invention relates to a re-control system, and discloses means of pro- a printed record of each operation initiated by patcher.

816,186 (1927). This invention relates to a risory system, and discloses means whereby tomatic operation of any one of a plurality of s will be recorded in printed form, the record ting the device number, the date, and the time ration.

324,207 (1927). This invention relates to rail-ossing control circuits, and discloses inductor s used as a means of initiating the circuit e.

832,118 (1928). This invention relates to a ling system in which key senders are employed nsmitting digits representing numbers to a re-location where the register panels are located, nels being of the lamp type.

882,010 (1927). This invention relates to a se- signalling system, disclosed in connection train dispatching system.

888,267 (1927). This invention relates to a re-control system, and discloses means by which a ity of substations are controlled in tandem over k line.

888,268 (1928). This invention relates to re-control systems in which a plurality of select-witches located in distant substations are oper-ynchronously from a central dispatcher's sta-

888,985 (1927). This invention discloses a se- switch capable of closing a plurality of cir-n a train dispatching system.

No. 1,900,499 (1929). This invention relates to selective signalling systems which will function on radio transmitted signals, and discloses means at a transmitting station for calling one, more than one, or all of its receiving stations, as the case may be.

No. 1,911,712 (1926). This invention relates to a signalling system in connection with carrier current installations.

No. 1,924,402 (1930). This invention relates to signalling systems, and discloses means for producing audible time signals.

No. 1,930,517 (1927). This invention relates to remote control systems and discloses an improved method of operation where a plurality of substations are connected in tandem over a trunk line.

No. 1,932,623 (1927). This invention relates to remote control systems, and discloses a rotary switch which advances both upon energization and de-energization.

No. 1,942,424 (1931). This invention relates to a signalling system which will enable consumers of electric power to make a study of their conditions in order to more evenly distribute the power consumption so that peak loads may be avoided.

No. 1,944,688 (1931). This invention relates to signal control systems, and discloses means whereby the output conductors of a number of previously recorded programs may be selectively connected with the input conductors of a broadcasting system.

No. 1,956,351 (1929). This invention relates to a signal control system actuated from a motion picture film.

No. 1,960,779 (1927). This invention discloses an improved sending device for use in connection with a train dispatching system.

No. 1,960,780 (1928). This invention relates to a signalling system, and discloses means for the routing of trains in and out of a railway terminal.

No. 1,960,781 (1930). This invention relates to a selecting system used in connection with a Power Supervisor's Board.

No. 1,968,078 (1929). This invention relates to a radio receiving device which will respond to and record only a predetermined signal.

No. 1,986,972 (1930). This invention relates in general to a selecting system used in connection with a Power Supervisor's Board, and discloses means for indicating the actual position of the various switch wipers after the same have been operated to their selecting positions.

No. 1,999,810 (1931). This invention relates in general to indicating systems, but more particularly to

an aircraft position indicating system for use at a dispatcher's office.

No. 2,008,909 (1929). This invention relates in general to signalling systems, but more particularly to a system for controlling and supervising the distribution of taxicabs throughout a number of districts of a large city.

No. 2,008,910 (1931). This invention relates to dispatching systems, and discloses means whereby any number of field stations may be interconnected, by a single set of two-line conductors, to a dispatcher's station.

No. 2,040,691 (1929). This invention relates to a radio receiving device which will respond to and record only a predetermined signal, and discloses certain relays which discriminate between the dots and dashes of the signal received.

No. 2,047,631 (1930). This invention relates to dispatching systems, and discloses means whereby any number of field stations may be interconnected, by a single set of three-line conductors, to a dispatcher's station.

No. 2,052,018 (1932). This invention relates to signalling systems, and describes means whereby a sending station transmits information to a plurality of receiving stations.

No. 2,053,774 (1933). This invention relates to indicating systems and more particularly to a dispatcher's display board, and discloses means whereby the principal of the Power Supervisor's Board may be applied to the dispatching of fire fighting apparatus.

No. 2,056,722 (1932). This invention relates to a selecting system used in connection with a Power Supervisor's Board, and discloses a push key sender which replaces the usual dial.

No. 2,231,671 (1935). This invention relates to the control of bells, lights and other safety apparatus located at the intersection of railroads and highways, and discloses means whereby the signal is operated at a predetermined constant time interval before a train reaches the intersection, regardless of the speed of the train.

No. 2,236,822 (1934). This invention relates to Municipal Fire Alarm Systems and discloses a combination of the radial type (which requires a pair of wires individual to each box), and the well known series type.

No. 2,275,146 (1935). This invention relates to a control system via carrier current superimposed on a power network, and discloses means whereby a large number of outlying water heaters may be controlled from a central dispatching point.

No. 2,275,147 (1935). This invention relates to control system via carrier current superimposed a power network and discloses the details of a r ceiver unit to be used in connection with Patent N 2,275,146.

No. 2,330,355 (1930). This invention relates to signalling system, and describes means for ind cating at several points the instant locations o large number of doctors who may be variously o cupied on the different floors of a large hospit

335 Stepping Switches: The market now affords a wi variety of stepping switches which may be used by t designer of remote control systems. The choice o particular switch is largely determined by (1) the r quired speed of operation, and (2) the current to carried by the wipers or brushes.

After the designer has completed his circuit sketch and operating specifications, it is a relatively simp matter for any manufacturer to make up a stock li showing his recommendations as to the relays a stepping switches best suited for the purpose. T current sales literature of all manufacturers shou be carefully studied in order that the designer may conversant with the latest developments in the a

Stepping switches in general fall into three catego ies; (1) Single Motion Switches - around and r turn. (2) Single Motion Switches - unidirection rotary. (3) Two Motion Switches - up, around a return. Switches typical of each category will be di cussed in the following sub-sections.

335 (a) Around and Return: The Single Motion Swit shown in Fig. 37 consists of a bank assembly, wipe assembly, and the mechanism required to move th wipers. The switch has a rotary motion only and, telephone parlance, is termed a "Minor Switch.

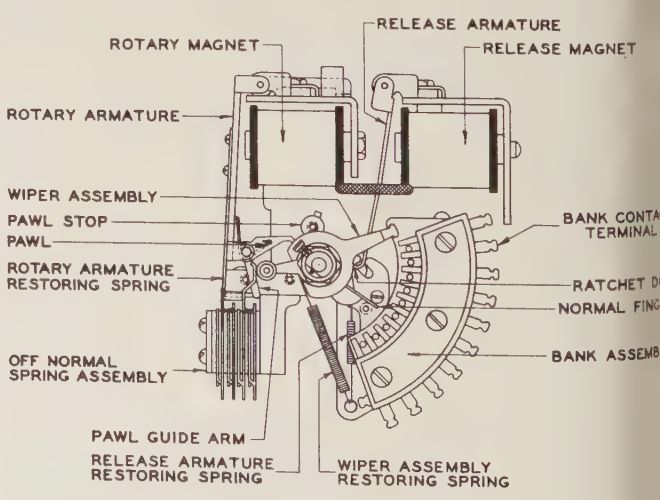



Fig. 37 - Minor Switch Mechanism.

Each level in the bank assembly has ten sets of con tacts arranged in an arc. Actually, the bank assembl on a minor switch may be one, two, or more level deep depending on the circuit requirements. Eac level has associated with it one pair of wiper springs

y, the upper surface of each level consists of ividual contacts, while the bottom surface is a egment (called a contact common). The pair of springs merely closes the circuit from the par- top contact upon which it stops, to the contact on.

trol the movement of the wiper assembly, two magnets are provided. One is for rotary step- nd one for release. The armature of the rotary et carries a pawl which operates the rotary nism. When incoming pulses energize the mag- armature is attracted, and the pawl engages the teeth on a ratchet wheel, causing the ratchet n on its axis. The wiper pairs are rigidly led to this ratchet and thus step with it. The r of steps corresponds to the incoming pulses. spring attached to the rotary armature provides ing tension for the armature after each energi- of the rotary magnet.

tchet dog, which is merely the hooked end of ease magnet armature, is controlled by the re- armature restoring spring and the magnet. It ss the teeth on the ratchet wheel and retains the on the contacts to which they have been stepped rotary mechanism. As the wipers step, the assembly restoring spring, which is attached wiper assembly, increases its tension. This restores the wipers to their normal position ep to the left of the first contact) as soon as the magnet operates and disengages the ratchet om the ratchet wheel.

nor switch is equipped with a spring assembly ated M.S.O.N. springs (minor switch off-normal s). These are actuated on the first rotary step, urn to normal when the switch releases.

Unidirectional Rotary: The Unidirectional Switch shown in Fig. 38 uses a semi-cylindrical hich has from one to six levels, each level ing twenty-five contacts. A pair of double- l wipers rotates over each level of contacts. one end of a wiper is in engagement with the ontacts, the other end is free from the bank. is arrangement, a unidirectional motion is ed to the wipers, which are engaged with the all times; that is, when one end of the wipers ing contact twenty-five, the other end is ap- ing contact number one. By rotating through a rcle, the wipers successively step over all s. The electrical circuit to each wiper is ined through a spring brush which makes con- th the hub of the wiper.

iving mechanism comprises a ratchet wheel, ed on the wiper shaft, the ratchet being engaged wl pivoted to the armature of the motor magnet. he motor magnet is energized, the pawl is with- drawn from the ratchet wheel so that it can engage the next tooth when the motor magnet is de-energized. A retractile spring, tensioned against the motor mag-

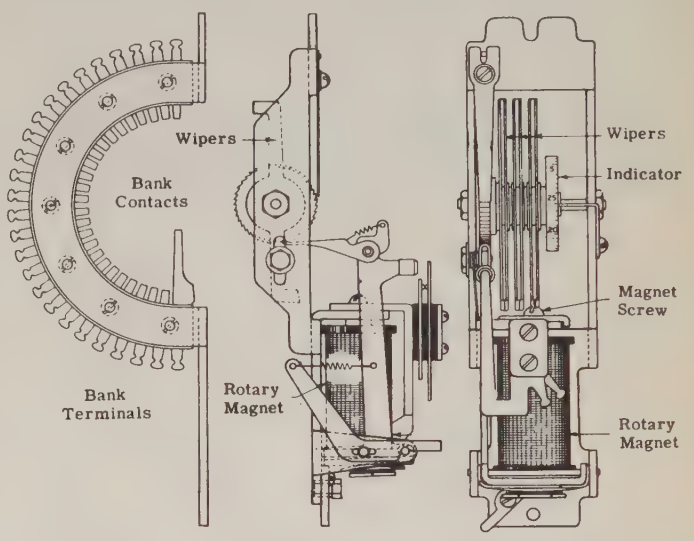



Fig. 38 - Rotary Switch Mechanism and Bank.

net armature, causes the pawl to engage the ratchet tooth and step the wipers to the next position as the motor magnet releases.

Certain rotary switches are designed to advance their wiper assembly upon the energization of the associated motor magnet.

335 (c) Up, Around and Return: The Up, Around and Return Switch shown in Fig. 39 is one of the very early "Strowger" switches.

The Strowger mechanism is an electro-mechanical device capable of imparting the following movements to a wiper carrying shaft; (1) the shaft may be raised vertically any number of steps from one to ten, then (2) the shaft may be "rotated in" any number of steps from one to ten, after which, (3) the shaft may "release" to its normal position by first rotating backward under the influence of a spring, and then falling by gravity.

The old patent drawing well illustrates the Strowger switch mechanism, although it shows some parts that are not used on modern switches. Note particularly; (1) the sequence switch made up of the side switch wipers (S-1, S-2, S-3 and S-4), the spider arm (SO), the escapement springs (SPGS) and the private magnet (PM); and (2) the toggle action by which the rotary magnet (RM) interrupts its own circuit by way of interrupter springs (A) and (B) and rotary arm finger (C).

(A) Sequence Switch: The side switch in Fig. 39 is made up of four wipers; they are mounted on one

block and swing on two pivots, so that all move together. The side switch has three positions, each wiper having, therefore, three bank contacts. Attached to the side switch block is the spider arm (SO) by which the movements of the side switch are controlled. The spider arm has a tendency to move the side switch from position 1 to position 3. This is resisted by the escapement springs (SPGS) which are mounted on the armature of the private magnet (PM). The escapement is composed of four teeth, two on the upper spring and two on the lower spring.

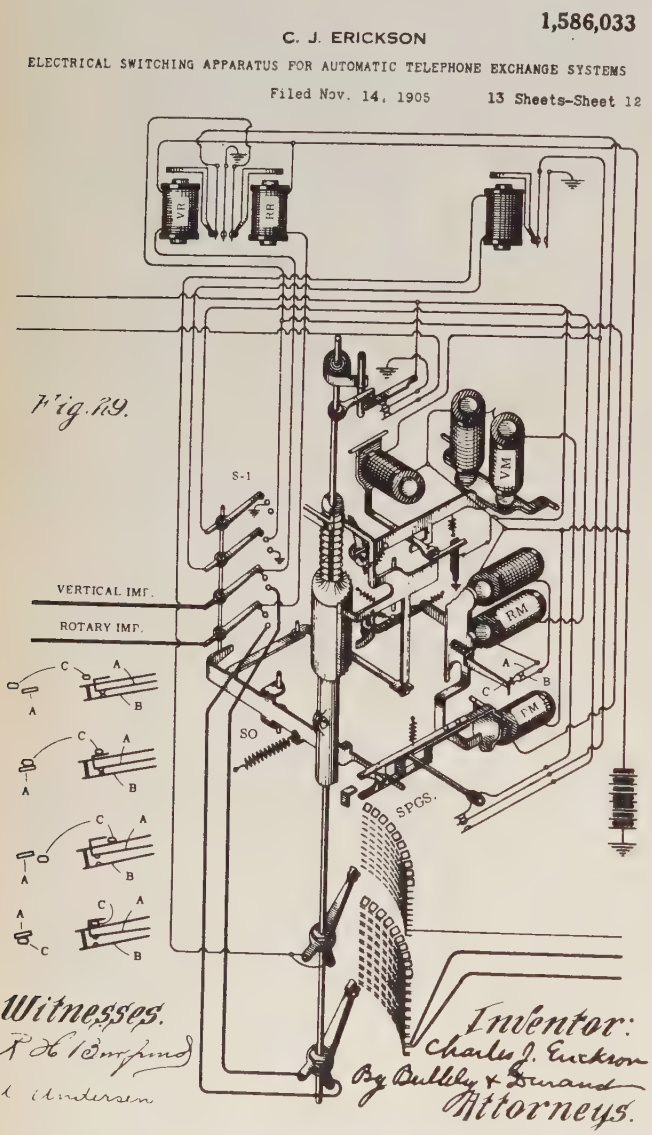



Fig. 39 - Strowger Switch Mechanism. This old patent drawing well illustrates the Strowger switch mechanism, although it shows some parts that are not used on modern switches.

When the private magnet is energized, the escapement springs on its armature move downward, allowing the end of the spider arm to slip forward a little and come to rest against the first upper tooth. Although this allows the side switch wiper to move a little, the motion is so slight that it does not change the electrical connection. When, however, the private magnet is de-energized, the end of the spider arm is unable to catch on the first lower tooth, but slips to the and is caught by the second lower tooth. This allo the side switch to move from position 1 to position A repetition of the energizing and de-energizing the private magnet will result in moving the s switch from position 2 to position 3.

(B) Toggle Action of Rotary Interrupter: Interrupt spring A carries an extension as indicated in the e larged view at the left of the figure. During the fo ward (energizing) movement of the rotary magn armature when acting as a self-interrupted rotar C passes above A and holds A and B in engageme until the armature is fully operated. During the bac ward (de-energizing) movement of the rotary arm ture, C passes below A and thus holds A and B out engagement until the armature is fully retracte

(C) 3-Wire Driving Circuit: The switch shown Fig. 39 is a selector; which means that the vertic movement is in response to incoming dial pulse while the subsequent rotary movement is automati in search of an idle (ungrounded) trunk.

Vertical impulses pass by way of S-3 in first positio to VR. Vertical relay VR repeats each impulse b way of break springs on PM to vertical magnet VM The shaft and wipers are thus raised to the desire level of bank contacts.

The series of vertical impulses is followed by a singl rotary impulse (see Sec. 307) which passes by way o S-4 in first position to RR. Rotary relay RR repeat this impulse to private magnet PM.

The momentary energization of PM permits the side switch to pass to second position.

(D) Searching For Absence of Ground: When the side switch passed to second position, ground by way of S-1 is passed to the lower rotary magnet RM and thence through rotary interrupter springs A and B to the upper RM and battery.

The rotary magnet now energizes; (1) rotates the line and private wipers into engagement with the first contact in the previously selected level, and (2) mechanically operates the armature of private magnet PM.

If the first private (upper) bank contact is busy (grounded), a circuit is closed by way of the private (upper) wiper, an unmarked relay, S-2 in second position, and thence to private magnet PM.

So long as the private wiper engages grounded bank contacts; (1) private magnet PM will remain energized and, (2) rotary magnet RM will continue to interrupt its own circuit and advance the wipers step-by-step across the level.

Private magnet PM will de-energize (it is hoped) when the first ungrounded private bank contact is reached. The side switch then passes to third position, opening the circuit of rotary magnet RM at S-2.

# PART D - CIRCUITS

e earlier editions of this text the writer took e in presenting "modern authoritative circuits". can no longer be done, as the modern circuits t stay put long enough to get into print.

rmost that can be said for the circuits here pre- ed is that they are typical, and in many cases are posites made up especially for instruction pur- s.

ttempt has been made to present a preferred em of circuit explanation. Most of the known oaches have been utilized at one place or another attempt to familiarize the reader with the var- ns which he will be likely to encounter in read- trowger literature.

Subscriber Station Circuits: The early 2-wire phone circuit shown in Fig. 1 consists of four s. Talking apparatus (a transmitter in series a non-polar receiver), ringing apparatus, se- ing apparatus (dial) and the switching device.

(a) The Dial: The dial enables the calling party ontrol the automatic switching mechanisms which blish the telephone connection. It has three cipal functions which are; (1) to deliver im- ses, (2) to short-circuit the parts of the tele- e which introduce unnecessary resistance in the ing circuit, and (3) to prevent the dialed im- es from clicking in the receiver.

impulse springs are so mounted that the impulse , while revolving, will break and make the spring acts a number of times corresponding to the digit ed.

shunt springs are used to shunt the receiver and smitter circuits while the dial is operating or is n off-normal position. The shunt springs are so nted that, whenever the dial is in an off-normal tion, they will be operated and when the dial again rns to normal, the shunt springs will be restored ormal. This shunting prevents the impulses from g heard in the receiver during dialing, and also vents the variable resistance of the transmitter m affecting the character of the operating impulses.

The Delayed Impulse Dial: In the simple dial a lobed impulse cam makes as many "half revolu- s" as there are units in the digit dialed. Each revolution courses a momentary break of the ulse springs.

he delayed impulse dial, the impulse cam makes more "half revolution" than there are units in digit dialed. The last half revolution of each series endered ineffective by a cam which moves the impulse springs out of the line of travel of the impulse cam. Thus the impulses delivered correspond to the digit dialed, even though the impulse cam makes one extra half revolution at each operation of the dial. For further discussion see Sec. 201 (c).

400 (b) Circuit Reading Of Fig. 1: At the right of the figure is shown the circuit of a line and release relay; they are of particular interest on account of the fact that they appear in practically all automatic switches.

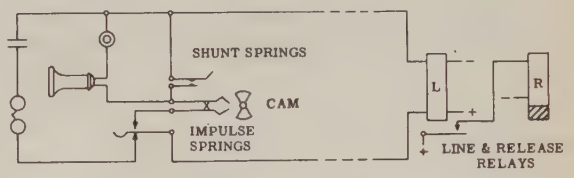



Fig. 1 - Early 2-Wire Telephone Circuit.

When the receiver is removed at the sub-station a circuit may be traced from negative battery, through the upper winding of relay L, transmitter, receiver, impulse springs, upper contact of switch hook, lower winding of relay L to ground. The current flowing in this circuit will cause relay L to energize. Relay L, upon energizing, will close a circuit from negative battery through relay R, make springs on relay L to ground, whereupon relay R will become energized.

Now let us assume that the subscriber dials the digit 1. When the dial is released and as it returns to normal, the cam is given a half turn, and one of its wings momentarily forces the impulse springs apart as it passes between them. This momentarily opens the circuit of line relay L, relay L de-energizes for an instant and in turn opens the circuit of release relay R. Relay R remains energized even though its circuit was opened momentarily, for the reason that it is a slow to release relay. If the subscriber had dialed the digit 4, the cam would have been rotated twice, thus opening the line circuit 4 times. From the foregoing we can conclude that for each figure called by the subscriber the line circuit will be momentarily opened a like number of times. From the discussion so far it is evident that each time the dial is operated a series of clicks will be heard in the receiver.

To overcome this a pair of shunt springs are provided as shown. As soon as the dial is moved to an off-normal position these springs come together and maintain a shunt around the transmitter and receiver until such time as the dial returns to normal. It is evident that if the shunt springs were not used, the resistance of the subscriber's loop might vary, during the dialing period, due to a change of resistance in the transmitter. This would tend toward irregular operation of the central office mechanism and is obviated by using a shunt around the receiver and transmitter during the dialing period.

400 (c) Modern Telephone Circuit: In Fig. 2 is shown a modern telephone circuit, its operation, from a transmission viewpoint, is decidedly controversial and an explanation will not be attempted here.

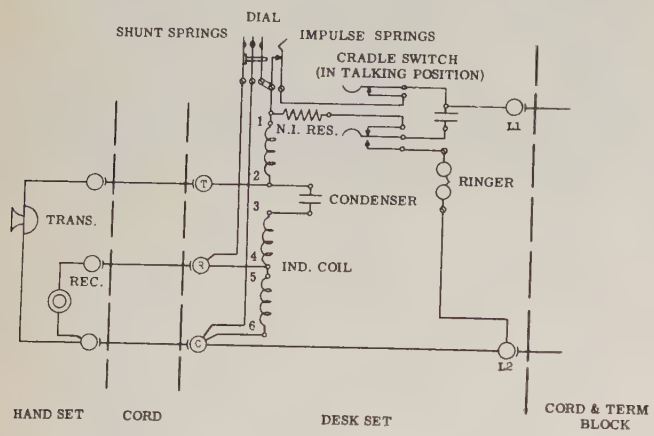



Fig. 2 - Modern Monophone Circuit.

For further discussion of telephone circuits and components see AT 7-27, AT (Smith) 1-28, AER (Pye) 9-35, STJ (Smith) 12-35 and STJ (Pye) 12-36.

401 Line Circuits: No matter what type of non-numerical switch may be used, each line must be equipped with the equivalent of a line and cut-off relay. Various typical line circuits are discussed in this section.

401 (a) In Fig. 3 is shown a line circuit to be used with a plunger line switch. (In actual practice both relays are a part of the line switch).

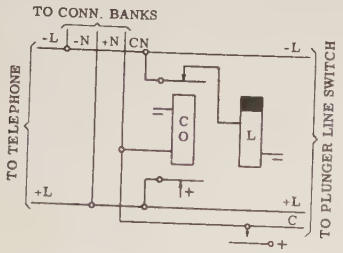



Fig. 3 - Line Circuit Of Plunger Line Switch (Closed Normals).

(A) When the receiver is removed, a circuit is completed from - battery through line relay L, upper break contacts of relay CO, the line loop, and through the lower break contacts of relay CO to ground.

Relay L operates; (1) Closes the circuit of cut-off relay CO and (2) places ground on the CN normal to make this line busy in the banks of the associated connectors.

In due time the line switch operates to extend the connection to the switch ahead, whereupon ground is returned on the C lead to hold relay CO and maintain ground on CN.

Relay CO operates and cuts off relay L (clears the line of attachments).

Relay L restores after an interval sufficient to perm the return of ground on the C lead.

(B) When the receiver is restored to the switch hoo ground is removed from the C lead by the connecto whereupon relay CO restores and guarding ground removed from the CN lead in the banks of the associ ated connectors.

(C) When this line is called by a connector, groun is placed on the CN lead, whereupon relay CO operate to clear the line of attachments.

(D) Note that here the -N and +N normals ar "closed," i.e., tied directly to the -L and +L.

401 (b) In Fig. 4 is shown a similar circuit, excep that the +N and -N normals are "open". For furthe discussion see Sec. 205 (e).

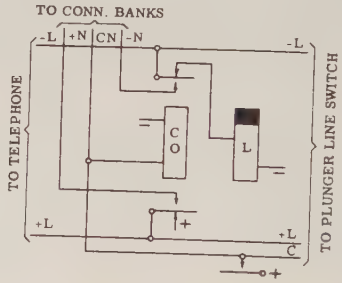



Fig. 4 - Line Circuit Of Plunger Line Switch (Open Normals).

401 (c) In Fig. 5 is shown a line circuit to be used with a non-homing rotary line switch. Note that the -L, +L and C leads to the rotary line switch proper come from make contacts on relay CO. This is necessary because the rotary line switch wipers continue to stand where last used.

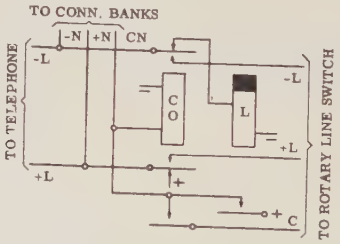
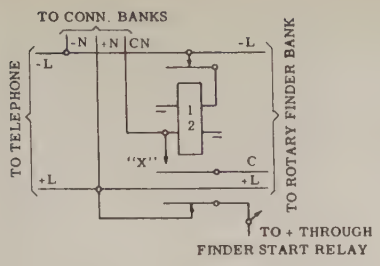



Fig. 5 - Line Circuit Of Non-Homing Rotary Line Switch.

Because of the above fact it is also necessary to provide a mechanical inter-locking device between relays L and CO. The device is such that relay CO cannot operate fully unless relay L has previously operated. The result is that relay CO, on incoming calls, will operate sufficiently to break all its back contacts but not sufficiently to close its make contacts. See Fig 1, page 68.

401 (d) In Fig. 6 is shown a line circuit to be used with a rotary finder. The relay shown is a combined line and cut-off relay. This is an illustration of a "two-step" relay. The upper (line) winding has only sufficient power to operate the "X" contact.




ig. 6 - Line Circuit For Use For Use With A Rotary Finder.

) In Fig. 7 is shown a line circuit to be used . Strowger finder. This is another "two-step" The three windings, when energized in series, only enough power to operate the two pairs of contacts.

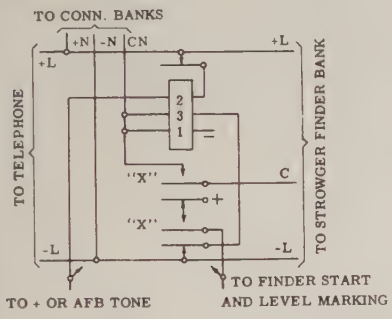
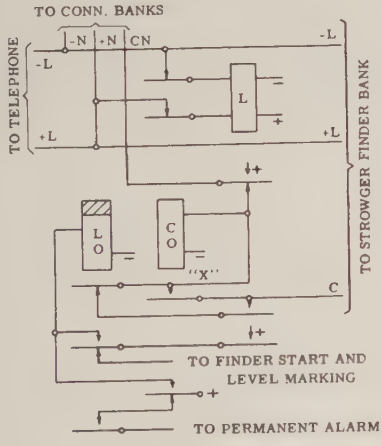



Fig. 7 - Line Circuit For Use With A Strowger Finder.

) In Fig. 8 is shown a three relay "line lock- circuit to be used with a Strowger finder. Re- l of the receiver closes the circuit of relay L, operates to; (1) ground the CN lead; (2) Mark lead with battery through relay CO; and (3) ground on the level marking and finder start




ig. 8 - Line Lock-Out Circuit For Use With A Strowger Finder.

and is placed on the C lead when the finder reaches bank contacts associated with this line, where- :

y CO operates; (1) locks inself to the C lead at "X" contacts; (2) opens the circuit of relay L; (3) closes the circuit of relay LO.

Relay L de-energizes and connects the CN lead to the C lead.

Relay LO operates, but without effect at this time.

In the event that dialing does not take place within a determined time interval, ground is momentarily removed from the C lead, whereupon:

Relay CO restores; (1) reconnects relay L the line, (2) opens the circuit of slow to release relay LO, and (3) places ground on the permanent alarm lead.

Relay L again energizes and closes the locking circuit of relay LO, before that slow to release relay has had time to de-energize.

The line is now locked out, and the finder link freed.

This circuit permits reverting calls to be made without tying up trunking equipment, see Sec. 218 (c)(B).

For further discussion of line lock out, see Section 134 (a).

402 Non-Numerical Switch Circuits: The present popularity of the Line Finder would warrant its occupying first place in a discussion of circuits, were it not for the fact that it is very complex. The novice had best acquire considerable skill in reading circuits before he tackles that subject.

The non-numerical switch circuits will be discussed in the following order; (1) Keith Line Switch Circuit (Sec. 402 (a); (2) Master Switch circuit (Sec. 402(b); (3) Self-Aligning Line Switch circuit (Sec. 402 (c); (4) Rotary Line Switch Circuit (Sec. 402 (d); and (5) Finder Switch Circuit (Sec. 405).

402 (a) Keith Line Switch Circuit: The circuit of the Keith line switch, Fig. 9, has its duties divided into two parts; (A) those duties which must be preformed while the subscriber is calling into the exchange, and (B) those duties to be preformed while the subscriber is being called by some other subscriber through a connector switch.

The details devolving upon the lineswitch circuit while calling are:

(1) Operate the plunger to extend the circuit to the first selector; (2) Clear the line of line relay and ground connections. (3) Drive away other plungers so that privacy of the trunk may be secured; and (4) Protect the subscriber's line at the connector bank so that no connector can seize this line.

We will assume that the reader understands the mechanical structure of the Keith type line switch. This has been described previously in Sec. 178 (a). Each subscriber possesses a line switch consisting of a magnet and plunger and a bank of ten sets of contacts. Corresponding sets of contacts from all the banks in a common group are wired to trunks leading to first selector switches.

All the plungers in a group are controlled in their normal position by a guide shaft, so that all will point toward a given trunk. This position is determined by a master switch, which possesses the ability to move the guide shaft away from any trunk which is busy.

The line switch circuit contains a line relay, a magnet, a plunger arm, and plunger with bank contacts. For the sake of clearness of circuits, the reader is asked to accept the diagram as it stands and to imagine that the plunger arm can act to depress the curved bank springs (associated with this particular line switch) into engagement with the stationary contacts which are associated with one particular trunk.

No attempt is made in this diagram to show the mechanical relation which actually exists, since we will at this point emphasize the electrical circuits.

The apparatus immediately connected with the line is quite similar to that found in manual common battery boards. It consists merely of a line relay, connected from negative battery to one line wire, while the other terminal of battery is connected to the other line.

A cut-off relay bearing two coils, P.D.C. and B.C.O., can cut off the ground and line relay from the line circuit. For reasons to be explained later, the line relay is equipped with a copper collar so as to make it slow in falling back after the current through its winding has been cut off.

The magnet which drives a plunger into a bank and thus connects the bank springs and contacts, is operated by a very simple circuit extending from negative battery through a contact on the line relay to ground. It is a low resistance coil and possesses great power. When energized, it can operate not only the cut-off springs at the left, but the plunger arm, at the right.

Three trunk wires are run from the stationary contacts to a first selector or connector. The -T and +T run to the two windings of the line relay of the first selector and thence to the opposite terminals of the battery.

The release trunk RT runs to the contact of a relay called the "release relay," whose function will be more minutely described when we treat the selector circuit. The purpose of the release relay is to ground the release trunk and thus secure the connection from being released as well as to guard it from intrusion.

Normally, no current can flow through the line circuit becuase it is open at the condenser in the subscriber's telephone. This is precisely the condition which exists in every manual common battery switchboard. The circuit is, however, closed as far as alternating current is concerned and, therefore, under proper conditions, ringing current can be sent over the line to operate the bell.

When the subscriber desires to make a call, he first removes the receiver from the hook. This preliminary act will result in the operation of the line switch, extending his telephone line to the first selector and moving the plungers of all other subscribers in the same group, to other trunks. All this occurs without the subscriber's volition or knowledge, and is entirely preliminary to the operation of selecting a number.

The receiver being off the hook, current flows from ground, through a back contact on the cut-off relay, through +L, through talking apparatus of the telephone, back to the central office through -L, through

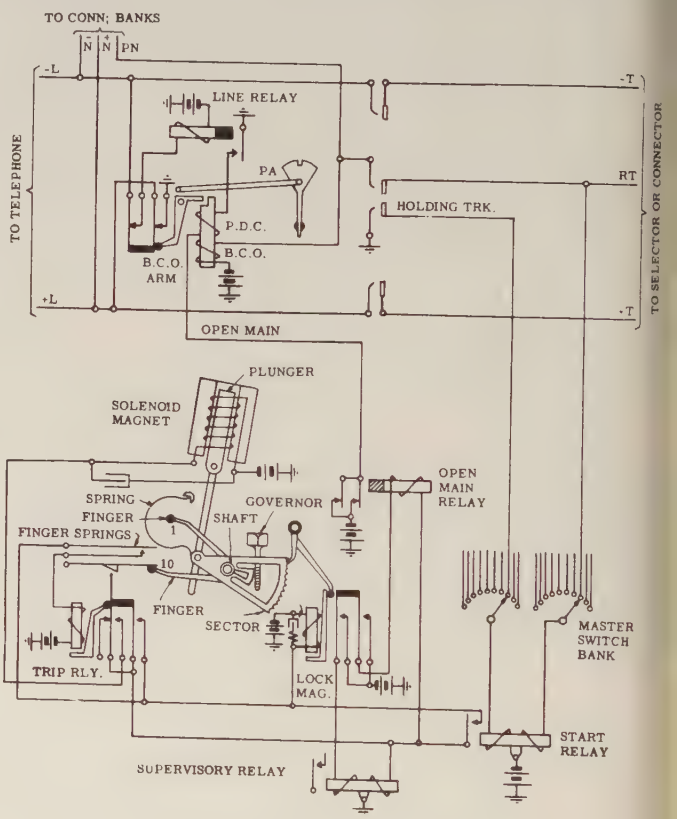



Fig. 9 - Circuit of Keith Line Switch.

another contact of the cut-off relay, through the winding of the line relay, to negative battery. The line relay, therefore, pulls up and closes the circuit of the pull-down coil P.D.C.

This coil with one movement cuts off the line relay and ground and forces the plunger into the bank, closing each of the movable springs against its corresponding bank contact. Because the line relay is slow to release, the pull-down coil will remain energized for a fraction of a second after the cut-off springs have been opened.

The line is now extended to the line relay of the first selector which, pulling up, energizes the release relay of the same switch. The release relay places a ground upon the release trunk RT and thereby draws current through the bridge cut-off coil, B.C.O., locking the magnet in its operated condition so that the

elay may now fall back, which it will do when gnetic energy has been spent.

ame grounding of the release trunk by the re- relay protects the call from two sources:

It places a ground on the private normal, P.N. g to the banks of the connector switches, whose t is to deliver calls into this group. Any con- which attempts to make a call will find this e normal wire grounded and will, therefore, be to complete the connection.

d: It places a ground upon the contact of the r bank to which it is wired. This will energize arting relay of the master switch so that the will remove the remaining idle plungers to other trunk, which, at this moment, is not Whenever the wiper belonging to the master ch bank finds an ungrounded contact, the start- lay of the master switch will fall back and he guide shaft with the idle plungers ready to an idle trunk.

a call is to be received from another line gh a connector, the line switch must clear the relay and ground without operating the plunger. plunger were operated, it would necessarily y a trunk and first selector, thereby withdraw- em from being used by other people.

a connector calls for a line, the test as to the tion of the line is made by means of the private of the connector switch. If the private normal, is found without a ground connection, the con- r proceeds to put a ground on it. This will ener- nly the high resistance coil, B.C.O., of the switch.

coil is much weaker than the pull-down coil, C. It is able only to move the cut-off springs e left, without affecting the plunger arm P.A., e right, and serves to cut off the ground con- on from +L, and the negative battery and line from -L, so as to leave the line perfectly of any attachments.

arginal action of the line-switch magnet is ured by arranging the two armatures at dif- ent distances from the pole of the magnet. A angular notch is cut in the end of the line switch net. The end of the armature which operates the off springs is adapted to fit into this notch and and not very far away from the pole.

plunger arm, P.A., though pivoted on the same ers as the little armature, stands somewhat ner away from the pole. Thus, each armature a different length of air gap and, consequently, a rent amount of reluctance to the passage of mag- sm. The pull-down coil, P.D.C. is sufficiently erful to create enough magnetism to attract both atures.

The bridge cut-off coil, B.C.O., has enough power to hold both armatures after they are once attracted. This is because when the armatures are in contact with the pole, the air gap is very short and, consequently, the reluctance very little.

The small number of ampere-turns will suffice to produce much more magnetism than could be produced by the same number of ampere-truns through a larger air gap. Hence, it follows that although it requires a greater mechanical force to pull the armatures into place than one would suppose, a weaker coil is successful in holding them because of the greater efficiency of the magnetic circuit when the armatures are against the pole.

When the private normal, P.N., is grounded, current will flow through the B.C.O. and pull down the small armature at the left and cut off the apparatus as before described.

402 (b) Master Switch Circuit: The duties of the Master switch circuit, Fig. 9, may be divided into two parts:

First, the duty of keeping the shaft and plungers in such a position that all the plungers will be pointing toward the contacts of an idle trunk line.

Second, the duty of preventing any line switch from operating during the time that the master switch is hunting an idle trunk.

This is done by disconnecting the negative battery from the wire leading to the pull-down coils. This wire is designated as the "open main."

When a master switch is to control only 50 lines, it is placed on the line switch upright in the middle of a single swinging shelf of 50 line switches, with a group of 25 above and the other 25 below. During the selection of an idle trunk, the shaft controlling the position of the line-switch plungers is rotated by means of a U-shaped spring. When allowed to operate, it will rotate the shaft in a counter-clockwise direction, looking at it from above.

Since the trunks are numbered from 1 to 10 (left to right), the action of the spring will rotate the plungers and shaft from trunk No. 10 backwards toward trunk No. 1. This motion is controlled by an escapement which consists of a sector mounted on the shaft and a lock lever mounted on the frame of the master switch.

The lock lever has a small steel roller on its end, which rests in any one of ten notches in the edge of the sector. The lock magnet controls the position of the lock lever. Whenever the lock magnet is energized, the lock lever is pushed away from the sector so that the spring will be allowed to rotate the shaft.

Whenever the lock magnet is de-energized, the lock lever springs toward the sector, the roller on its end drops into a notch and stops the shaft. A fly-ball

governor of the same type as is used in the calling device prevents the spring from moving the shaft too rapidly.

When the spring has rotated the shaft as far as it can that is, to trunk No. 1 a solenoid is employed for restoring the shaft and wipers to a position opposite trunk No. 10. This solenoid acts upon a plunger which is attached through a threaded rod leading to a crank on a lever projecting to the left of the shaft. This lever is in reality an extension of the sector.

The circuits used in connection with the master switch must provide for the control of the escapement, for the cutting off of the "open main" wire, and for the restoring circuit to bring the shaft back to the No. 10 position. These functions will be taken up one by one.

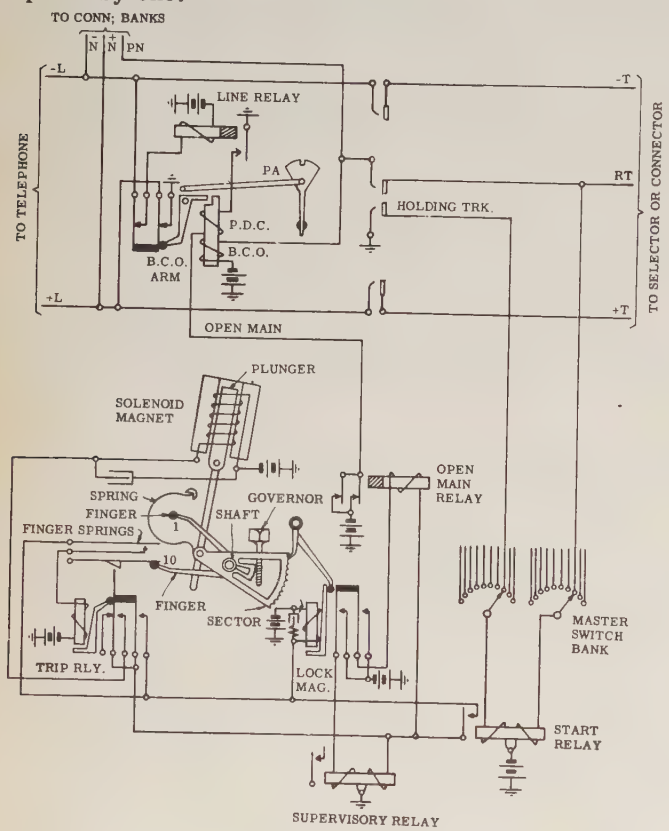



Fig. 9 - Circuit of Keith Line Switch. (Repeated)

The test circuit through which the master switch discovers the condition of the trunks extends from the tip of the wiper through the winding of the starting relay to negative battery. The ten wires which run from the master switch bank go to the release trunks of each of the ten trunks over which the master switch presides.

It will be remembered that, whenever a line switch occupies a trunk, a ground is placed upon the release wire for the purpose of holding the connection from being prematurely released. This ground connection also affects the condition of the corresponding master switch bank contact, so that the starting relay will always be energized when the shaft is pointing the wipers toward a busy trunk.

The control of the escapement is vested in the lock magnet, whose circuit is very simple and extends from negative battery, through its own winding, through a contact on the starting relay, and through a low resistance winding of the supervisory relay, to ground. A condenser is permanently wired in shunt with the lock magnet winding for the purpose of absorbing the magnetic energy of the coil which would otherwise be wastefully manifested by a vicious spark at the contact of the starting relay.

The lock magnet, whose duties have just been described, must be very quick-acting, both as regards energizing and de-energizing. Hence its winding is rather low in resistance so that it is to be classed as one of the powerful coils.

The restoring circuits come into play when the shaft has rotated counter-clockwise to trunk No. 1. In this position, finger No. 1 is in contact with the back finger spring, but the contact is not closed. If the shaft moves a little farther in the same direction, the finger springs will be closed.

This will energize the trip relay which, on pulling up, will be locked mechanically by the catch shown just above it. The springs of the trip relay now close the circuit of solenoid which, by pulling on the shaft, restore it to position No. 10.

When the subscriber takes his receiver from the hook, the line switch operates and seizes a trunk leading to a first selector. As a part of this operation, a ground is placed upon the release trunk by the first selector. This ground will be maintained upon the release trunk either by the first selector or some other apparatus until the end of the conversation.

The grounding of the release trunk causes the starting relay of the master switch to energize. This, in turn, closes the circuit of the lock magnet which, upon energizing, operates the "open main relay" and pushes the lock lever way from the sector. The "open main relay" operating, cuts off the "open main" wire, to prevent other line switches from acting.

The shaft now rotates by the force of the spring. During this rotation the master wiper tests each release trunk. As long as it finds a grounded contact, the starting relay will remain energized so that the lock magnet will not allow the lock lever to stop the rotation. But when the master wiper finds an ungrounded contact, the starting relay will fall back, the lock magnet will be de-energized and the escapement will stop the sector and shaft. This simple means is very effective in choosing the idle trunk.

When the shaft and plunger are pointing toward trunk No. 1, the bushing on finger No. 1 just touches a finger spring. When some subscriber occupies trunk No. 1, the ground thereby placed upon release trunk No. 1 energizes the starting relay. This pulls up the lock magnet and allows the spring to rotate the shaft still farther to the left, sufficient to close the contact between the two finger springs.

the starting relay is still energized the trip is excited over the following circuit: From nd, through the supervisory relay, through the act of the starting relay, through the finger gs, through the winding of the trip relay to neg- battery. The trip relay, pulling up, locks its sets of springs in contact.

solenoid now receives current over the following it: From ground, through the low resistance ding of the supervisory relay, through the left- set of springs of the trip relay, and through the noid winding to negative battery.

e same time that this occurs the lock magnet intained energized by the trip relay, regardless e condition of the master bank.

solenoid will now attract the plunger and pull the clockwise against the force of the spring until lungers arrive at trunk No. 10. During this re- stroke, the lock magnet is energized so that the pement is clear. The trip relay coil is not ener- d but the springs are retained closed by the catch.

the end of the stroke has been reached, finger 10 presses its bushing against the catch spring, using the springs of the trip relay. This cuts off current from the solenoid and the lock magnet h heretofore have been energized in parallel.

unk No. 10 is idle, the starting relay will de- gize, allowing the lock magnet to immediately o so that the lock lever catches the escapement etains the shaft at trunk No. 10. If, on the other , trunk No. 10 is busy, the starting relay will not back when the trip relay is unlocked, but will e the selection of an idle trunk exactly as has before described.

(c) Self-Aligning Line Switch Circuit: The line- hes described in Sec. 402 (a) remain where used the master switch picks up idle plungers. This not occur until enough calls have been made to se the guide shaft to pass the trunk where the plunger is resting, or a secondary shelf has be- busy. If the traffic is light, one subscriber who s several calls will thus use the same trunk over over. It also occurs, fortunately not very often, two subscribers call during the sweeping motion master switch. Then, when the open main closes, subscribers get the same trunk, resulting in a ble connection."

self-aligning plunger obviates the above draw- s. The tail of the plunger is not solid, but has arms, each carrying a roller at its end. A spring ses the arms together, with the flat blade of the e shaft between them. As before, the guide shaft es all idle plungers, keeping them opposite an trunk. When one line switch acts, its plunger is d into the bank, but the tail rollers do not leave guide shaft. As the shaft moves, the spring ls and permits the arms to separate. When the switch is released, the plunger is pulled out, free from the bank. Then the spring between the arms pulls the plunger into alignment, with the shaft in whatever position it may have.

The circuit of a self-aligning line switch (Fig. 10) shows a main electromagnet having the usual two armatures; (1) the plunger arm P.A. (operated only by the pull down coil P.D.C.), and (2) the B.C.O. armature. If the plunger arm has been attracted, it will be held by the B.C.O. winding only.

The pull down coil has permanent negative battery connection. Its ground connection comes through the line relay contact, part of the "chain."

The "chain" runs from ground at the back contacts of the start relay, through the 2200 ohm delay relay, through all the line relay contacts in series to the "open chain relay" 12,000 ohms to negative battery. Thus current flows all the time, and holds the open chain relay operated; if any line relay contact fails, the open chain relay will release and give notice of trouble. Any line switch from the fault to the open chain relay cannot call. Any lineswitch from the fault to ground can call as usual.

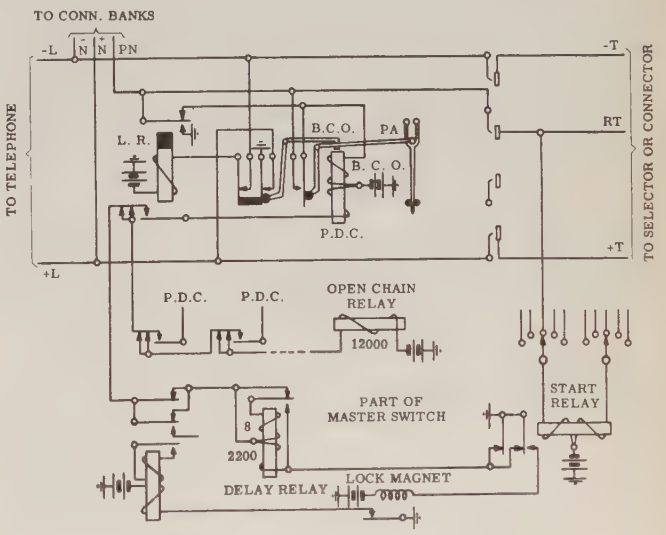



Fig. 10 - Circuit of Self-Aligning Line Switch.

When a subscriber releases, a short interval elapses until the plunger can become fully aligned. Though short, a subscriber might call again almost immediately and get a wrong trunk, one not known to be idle. The delay relay prevents this. Not enough current can get through the 2200-ohm winding to operate a pull down coil. The armature must act and put the 8-ohm winding in parallel with the 2200-ohm winding before the pull down coil can act.

When a subscriber takes down his receiver, the line relay grounds the release trunk normal (to connector banks) and cuts the pull down coil in onto the chain. As soon as the delay relay operates, the pull down coil actuates both armatures, extending the lines to the first selector. It also connects the release trunk to the line relay ground. Though the line relay is now

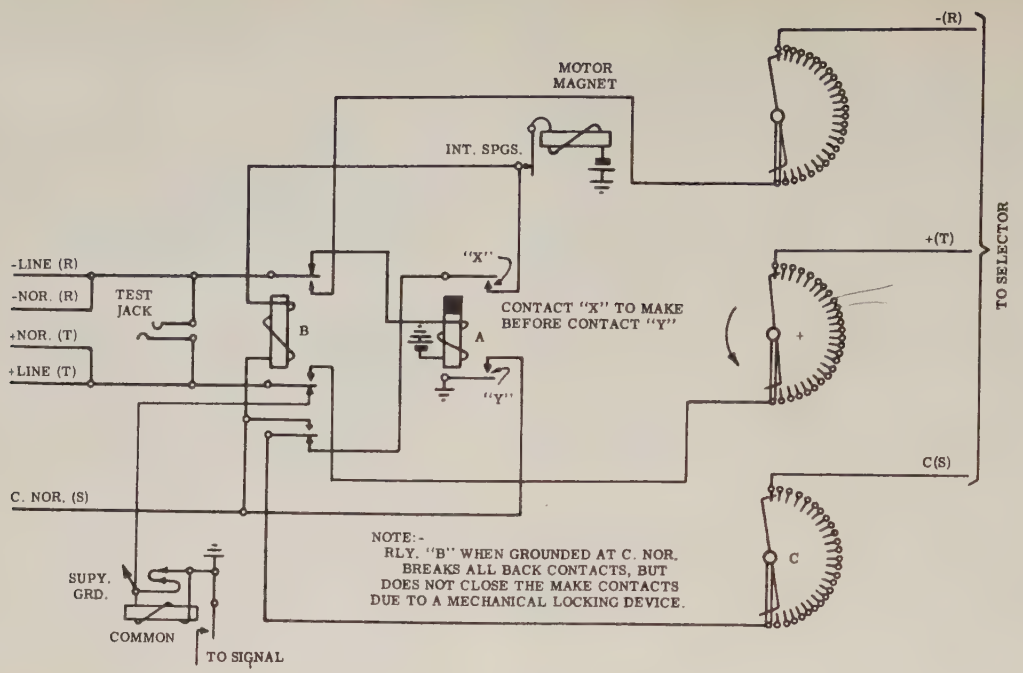



Fig. 11 - Circuit of Rotary Line Switch.

cut off, it will remain energized until the selector can ground the release trunk.

Immediately on plunging into the bank, the start relay operates, cutting off the chain ground and pulling up the lock magnet to cuase the seeking of an idle trunk. The chain control relay also acts as described.

Very soon the selector has grounded the release trunk, the line relay has released, and the chain is again closed at the line switch. The master switch also finds an idle trunk and all its relays restore to normal.

402 (d) Rotary Line Switch Circuit: A rotary line switch consists of a relay assembly, a mechanism and a bank.

(A) The relay assembly is composed of two relays; the line relay which is slow-acting, and the cut-off, or B.C.O., relay which is quick acting. A mechanical inter-locking device, interconnects the armatures of the two relays.

On incoming calls, with the line relay at normal, a finger on the cut-off relay armature strikes the end of the interlocking spring, permitting the cut-off relay armature to move only a distance sufficient to separate all break contacts associated with this relay but not sufficiently to close any of its make contacts.

However, when the line relay is energized on an outgoing call, a finger on the line relay engages an inclined plane at the end of the interlocking spring, moving the end of this spring out of engagement with the finger of the cut-off relay armature. In this case, when energized, the cut-off relay armature is allowed to move a full stroke, thus closing all make contacts.

(B) The rotary switch mechanism uses a semi-cylindrical bank which normally has three levels of bank contacts containing twenty-five contacts in each. A pair of double-ended wipers rotates over each level of contacts. When one end of a wiper is in engagement with the bank contacts, the other end is free from the bank. With this arrangement, a uni-directional motion is imparted to the wipers, which are engaged with the banks at all times; that is, when one end of the wipers is leaving contact twenty-five, the other end is approaching contact number one. By rotating through a half circle, the wipers successively step over all contacts. The electrical circuit to each wiper is maintained through a spring brush which makes contact with the hub of the wiper.

The control wipers, by means of which the test for an idle trunk is made, have more wiping surface then the others, so that, while rotating from one trunk to the other, they are always in contact with at least one control bank contact. This preserves the continuity of the circuit if successive contacts are grounded.

(C) Functions of Non-Homing Rotary Line Switch: The major functions of the non-homing rotary line switch are outlined below in the order in which they occur.

Outgoing Calls: On calls from the telephone, the functions of the line switch are; (1) to busy the line at the connector bank terminals against intrusion by incoming calls, immediately upon operation of the lineswitch line relay; (2) to automatically hunt and seize an idle trunk; (3) to extend the line through to the selected connector or selector; (4) to clear the line of all bridges or attachments; (5) to connect the subscriber's meter to the trunk meter lead, when message register service is provided; and (6) to restore the electrical circuits to normal when the calling

one disconnects. (The wipers remain in their perated position).

ing Calls: On calls to the telephone, the func- of the line switch are; (1) to prevent the line n from engaging a connector or selector trunk, 2) to free the line of all bridges or attachments.

ircuit of Non-Homing Rotary Line Switch: A l schematic circuit of the rotary switch used as --homing type primary lineswitch is shown in 1. While the circuit is for the 25-point line- it is likewise applicable to the 11-point, and the nt rotary lineswitch. The only circuit difference number of trunks to which the lineswitch has .

izure: When the receiver of the calling tele- is removed from the hookswitch to initiate a circuit is established from ground, through nding of the common ground-supervisory relay, ak contact on the bridge cut-off relay B, out he +line, through the telephone, back over the through another break contact on relay B, and e relay A to -battery, causing relay A to e.

eking An Idle Trunk: Relay A operating, its make contact, designated "X", to close If the trunk upon which the wipers are resting , ground from the control bank contact is con- to the motor magnet, through the control a break contact on relay B, the make contact lay A designated "X", and the interrupter s of the motor magnet, causing the motor mag- operate. It will be seen, that ground from the lead is connected to the upper terminal of by way of the "X" contact on relay A, before is connected to the lower terminal of that y way of the "Y" contact of relay A.

shunt is established around relay B, which s the latter relay from operating in case the are engaging a busy trunk. Ground is also ed to the control normal, through the make "Y" on relay A, to busy the line to incoming

eration of relay A also moves the locking out of alignment with the locking finger on the ure of the cut-off relay, allowing relay B to te a full stroke, when energized.

tor-magnet armature completing its stroke, he circuit to the motor magnet at the inter- springs. When the motor magnet is de- ed, its armature and pawl, restoring to nor- ler power of the restoring spring, step the to the next trunk.

rformance will be repeated very rapidly (from times per second) as long as the control encounters busy (grounded) control bank con- hat is, until an idle trunk is found. In the ase, the control wiper will not encounter ground and, therefore, the shunt around the cut-off relay B is removed.

(G) Engaging Idle Trunk: When an idle trunk is found, a circuit is established from ground, through the make contact on relay A designated "Y", the winding of relay B, the interrupter springs on the motor magnet, and the motor magnet winding to -battery, causing relay B to operate. Because of the high resistance of relay B, the motor magnet cannot operate when connected in series with that relay.

(H) Switching Through: Relay B operating, extends the telephone line and the control lead through the wipers and bank contacts to the switch ahead (connector or selector). The operation of relay B also disconnects ground from the +line, and -battery (through relay A) from the -line, de-energizing relay A and leaving the line free from any attachments.

Relay A is slow-acting, and remains operated to keep the ground circuit connected to relay B, until ground is returned over the control lead from the succeeding connector or selector which has been seized. Relay B is then held operated, until disconnection takes place, by the ground maintained on the control lead.

At the initiation of an outgoing call, should the trunk upon which the wipers are resting be idle, no stepping of the wipers will occur, and the line will be immediately switched through to the idle trunk, as previously described.

(I) Restoring Electrical Circuits To Normal: When the receiver at the calling telephone is replaced upon the hookswitch at the termination of a call, the loop circuit from the telephone is opened, and a switch ahead (usually the connector) disconnects ground from the control lead. This operation de-energizes relay B, permitting it to restore to normal.

Relay B releasing, disconnects the line and the control lead from the trunk and reconnects ground and -battery to the line; thereby restoring the line switch to normal.

(J) Incoming Calls: When the line connected to the rotary lineswitch under discussion is called, the connector places ground on the control normal lead. A circuit is then established from ground on the control normal lead, through relay B, the interrupter springs and the motor magnet to -battery, energizing relay B.

In this case, when relay B operates, the locking finger on its armature engages the end of the locking spring previously mentioned, preventing the armature of relay B from completing a full stroke.

The movement of the armature, however, is sufficient to disconnect ground from the +line, and -battery (through the winding of line relay A) from the -line, preventing relay A from operating and freeing the line of all attachments.

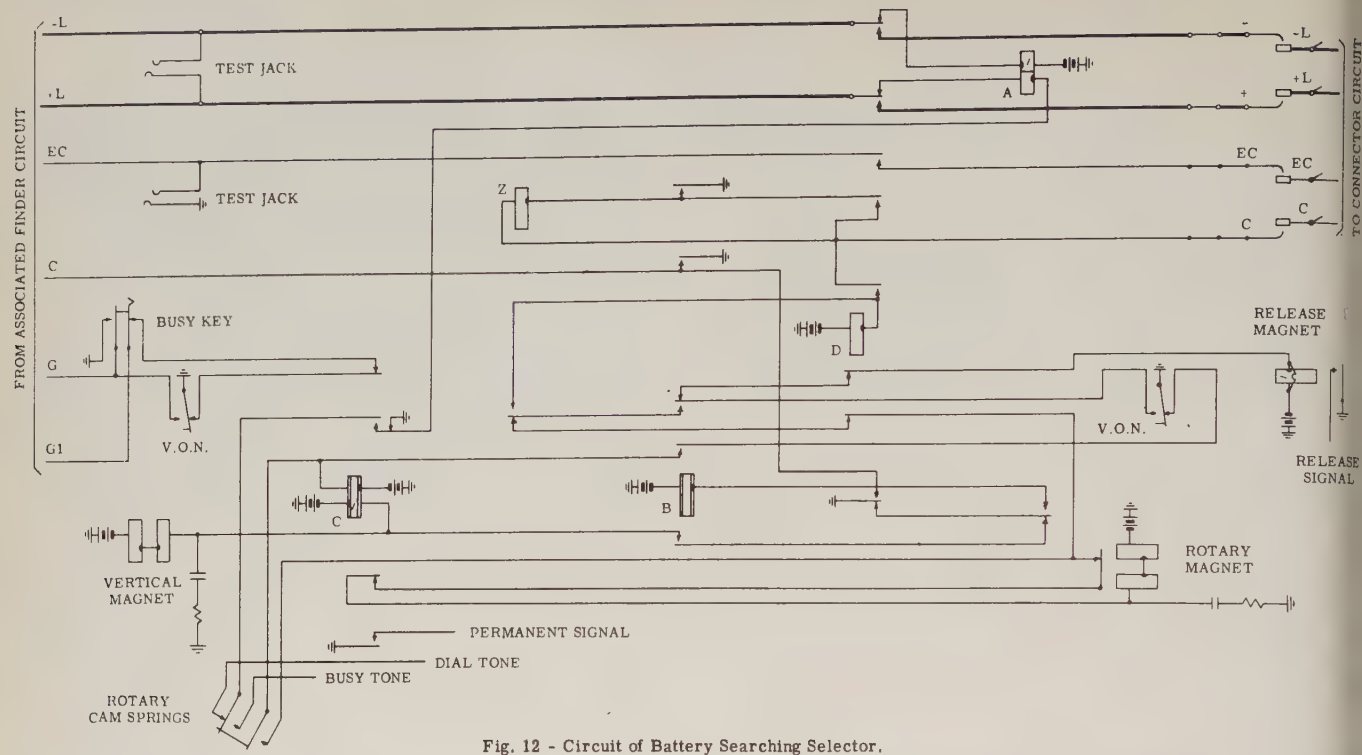



Fig. 12 - Circuit of Battery Searching Selector.

Since the mechanical interlocking device prevents the armature of relay B from closing its make contacts the telephone line is not extended through to the primary trunk on incoming calls.

403 Selector Switch Circuit: The circuit shown in Fig. 12 is that of a battery searching selector and is designed for use in a line finder system. The functions of this circuit are (1) Permits seizure over the +L and -L leads; (2) makes itself busy, returns holding ground to the preceding switch and returns dial tone to the calling line upon seizure; (3) steps the shaft and wipers to the dialed level in response to dial impulses; (4) automatically cuts in on the dialed level and seeks a free trunk; (5) seizes the first free trunk or returns busy tone if all trunks are busy on the dialed level; (6) releases when the switches ahead release or when the calling party disconnects if all trunks are busy; (7) provides for a permanent alarm if the switch is not stepped off normal after seizure, or released after an all trunks busy condition; and (8) provides for a selector release alarm if the shaft and wipers fail to restore to normal after the release magnet operates.

403 (a) Seizure: The absence of ground on the C lead of this selector makes the associated line finder free to the distributor. When the line finder is seized, it extends a loop through to the +L and -L leads, completing the circuit to relay A.

Relay A Operates: (1) Opens part of the pulsing circuit to the vertical magnet in multiple with #1C; and (2) closes the circuit to relay B.

Relay B Operates: (1) closes the circuit to #2C; (2) prepares the pulsing circuit to the vertical magnet and #1C in multiple; (3) opens an incomplete circuit to the release magnet; (4) prepares a circuit to the rotary magnet; (5) closes ground to the C lead; and (6) prepares a circuit to relay Z.

Relay C Operates: (1) Removes ground from the G1 lead; (2) closes ground to the permanent signal lead; (3) closes #2A to dial tone and ground on the dial tone lead and opens it from direct ground, returning dial tone to the calling party; and (4) opens the incomplete circuit to the rotary magnet.

403 (b) Raising The Shaft And Wipers To The Dialed Level (Relays A, B, and C operated): When the calling party dials the first digit, the dial pulsing springs at the calling telephone open and close the line loop a number of times equal to the digit dialed. This causes relay A to restore and re-operate as the line loop is opened and closed respectively. Each time relay A is at normal, the circuit is opened to relay B and closed to the #1 winding of relay C and the vertical magnet in multiple.

The vertical magnet operates on each ground pulse received from relay A to raise the shaft and wipers one step. On the first step the V.O.N. springs operate.

V.O.N. Springs Operate: (1) open further the ground circuit to the G1 lead; (2) open the circuit to #2C; (3) prepare the circuit to the release magnet, and (4) close ground to the G lead from the finder.

Relays B and C remain operated during impulsing since they are made slow-to-release by their sleeves. After the last pulse of the series, relay A comes to rest operated opening the circuit to #1C and the vertical magnet and closing the circuit to relay B.

haft and wipers are now on the dialed level. C holds operated momentarily.

Cutting In On The Dialed Level (Relays A, C operated): Relay C restores after a momen- elay as a result of its slow-to-release charac- cs.

C Restores: (1) closes part of the ground to the G1 lead; (2) removes ground from the nent signal lead; (3) replaces dial tone with ground to #2A; and (4) closes the circuit to ary magnet.

tary magnet operates, rotates the wipers to the ank contacts of the dialed level, and opens its rcuit thru its interrupter springs.

Trunk Hunting (Relays A and B operated): trunk on which the wipers are resting is busy, wiper encounters ground on the C bank contact shunts relay Z preventing its operation before tary magnet restores, and recloses its own . The rotary magnet re-operates, advances pers to the next trunk of the dialed level and its own circuit.

ipers are stepped over each busy trunk in the manner as explained above, until an idle one is or until the eleventh step is taken, if all trunks dialed level are busy.

Returning Busy Tone If All Trunks Are Busy s A and B operated): If all the trunks on the level are busy, the wipers are stepped as ex- l under Sec. 403 (d) until the eleventh step is stepping the wiper off the banks and operating n springs.

prings Operate: (1) close the circuit to #2C; pare the busy tone circuit; and (3) open part dial tone circuit.

C Operates: (1) opens part of a ground circuit G1 lead; (2) closes ground to the permanent lead; (3) transfers the circuit to #2A from ground to the busy tone lead to return busy the calling line; and (4) opens the circuit to ary magnet to prevent further operation.

lling party now receives busy tone an an indi- that all trunks are busy.

Seizing The First Free Trunk (Relays A and ated): When this selector finds an idle trunk, nce battery instead of ground is encountered C wiper on the C bank contact. This closes the it to relay Z which operates before the rotary restores.

Z Operates: (1) opens the circuit to the rotary to prevent further rotary stepping; and (2) the circuit to relay D.

Relay D Operates: (1) closes ground to the C wiper to seize the succeeding switch; (2) closes a multiple ground to the C lead; (3) closes its locking circuit to the C wiper; (4) opens the circuit to relay B; (5) closes the shunt relay Z; (6) closes the EC lead thru to the EC wiper; (7) opens the circuit to relay A; (8) closes the +L and -L leads thru to the + and - wipers; (9) opens further the incomplete circuit to the rotary magnet; and (10) opens further the incomplete circuit to the release magnet.

Relay Z Restores: (1) Opens the starting circuit to relay D; and (2) closes part of the circuit to the rotary magnet.

Relay A Restores: (1) opens further the circuit to relay B; and (2) closes part of the stepping circuit to the vertical magnet and #1C.

Since relay B is slow-to-release, it holds operated long enough to allow the next switch to be seized, and return ground over the C lead to prevent the release of relay D.

Relay B Restores; (1) opens an incomplete circuit to #2C; (2) removes a multiple ground from the C lead; (3) prepares the circuit to the release magnet; (4) opens an incomplete circuit to the rotary magnet; and (5) opens further the stepping circuit to the vertical magnet and #1C.

The calling line loop is now extended thru this switch to the +L and -L leads of the succeeding switch, and the connection with the dialed line may be completed with no further action in this switch.

403 (g) Release:

(A) Release From An All Trunks Busy Condition (Relays A, B and C operated): If all trunks on the dialed level were busy, the switch functioned as explained under Sec. 403 (d). When the calling party disconnects, the loop circuit is opened to relay A.

Relay A Restores: (1) opens the circuit to relay B; and (2) closes the circuit to #1C and the vertical magnet.

Relay B Restores: (1) opens the circuit to the vertical magnet and #1C; (2) closes the circuit to the release magnet; (3) opens the incomplete circuit to #2C; (4) opens part of the circuit to the rotary magnet; (5) removes ground from the C lead to release the associated line finder; and (6) opens an incomplete circuit to relay Z.

Relay C Restores: (1) prepares a ground circuit to the G1 lead; (2) removes ground from the permanent signal lead; (3) prepares the circuit to the rotary magnet; and (4) transfers #2A from the busy tone lead to ground.

The release magnet operates, ground the release signal lead and releases the shaft and wipers which restore to normal and release the cam and V.O.N. springs.

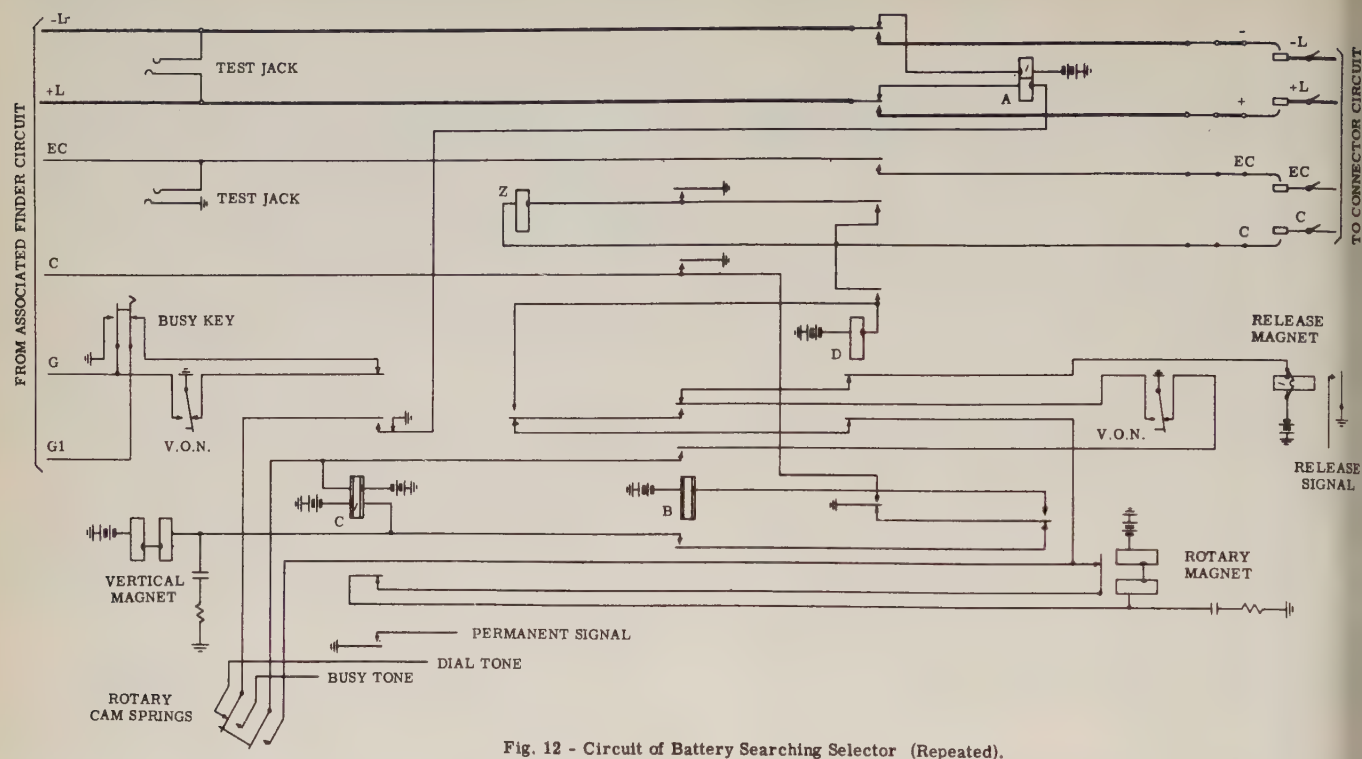



Fig. 12 - Circuit of Battery Searching Selector (Repeated).

Cam Springs Restore: (1) open an incomplete circuit to #2C; and (2) transfer the incomplete circuit to #2A from the busy tone to the dial tone lead.

V.O.N. Springs Restore: (1) remove ground from the G lead; (2) close ground to the G1 lead; (3) open the circuit to the release magnet; and (4) prepare the circuit to #2C.

The release magnet restores, removes ground from the release signal lead, restoring the circuit to normal.

(B) Release From A Completed Call (Relay D operated): When the succeeding switches restore, ground is removed from the C wiper, thus opening the circuit to relay D.

Relay D Restores: (1) opens further its own incomplete locking circuit; (2) closes the circuit to the release magnet; (3) opens ground from the C lead to release the associated line finder; (4) opens the EC wiper from the EC lead; (5) opens the +L and -L leads from the + and - wipers respectively; (6) prepares the circuit to relay A; (7) closes part of the circuit to the vertical magnet and #1C; (8) closes part of the circuit to the rotary magnet; and (9) opens the shunt to relay Z.

The release magnet operates, closes ground to the release signal lead and releases the shaft and wipers which restore to normal and release the V.O.N. springs.

V.O.N. Springs Restore: (1) remove ground from the G lead; (2) close ground to the G1 lead; (3) open the circuit to the release magnet; and (4) prepare t circuit to #2C.

The release magnet restores, removes ground fro the release signal lead and returns the circuit normal.

403 (h) Permanent Alarm: When this circuit seized, relay C places ground on the permanent alar lead to the TONE DISTRIBUTION & ALARM CIRCUI The permanent alarm lead is grounded by relay until the vertical stepping of the shaft is complete after which relay C restores and removes grou from the permanent alarm lead. If the calling par does not dial after seizing the switch, the associate permanent alarm signal lamp will glow.

If all trunks are busy on the dialed level, relay again operates closing ground to the permanent alar lead to give the alarm if the calling party does n disconnect after receiving busy tone.

403 (i) Selector Release Alarm: When the releas magnet operates to release the shaft and wipers, closes ground to the release signal lead to light lamp to signal the attendant, if the shaft does n restore to normal on the operation of the releas magnet.

403 (j) Busy Key: A busy key is provided whic when operated, opens the G1 lead from ground th the V.O.N. springs, and closes ground to the G lea making the associated finder circuit busy to preve this circuit from being seized.

403 (k) Test Jack: The test jack is provided for us in testing this circuit or monitoring calls. Springs

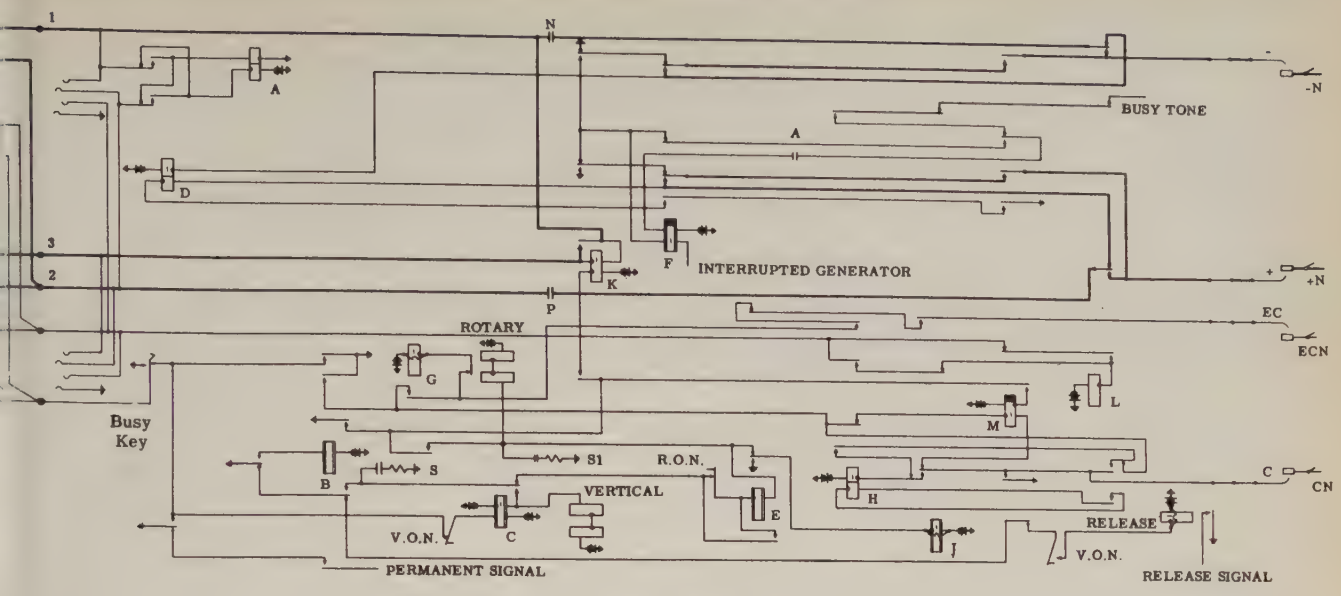



Fig. 13 - Circuit of Connector.

connect the test set to the -L and +L leads, 3 connects to the EC lead, and spring 4 to 1.

Spark Suppression: The 200 ohm resistor in with condenser S connected from ground to a nal of the vertical magnet prevents excessive ng at the impulsing contacts of relay A during al stepping. Condenser S1 in series with a 10 esistor connected from ground to a terminal of ary magnet prevents excessive sparking at its terrupter contacts during trunk hunting.

n-inductive resistor connected across the wind- he release magnet prevents excessive sparking acts of the V.O.N. springs during release.

connector Switch Circuit: The connector circuit in Fig. 13 is designed for use with a battery ding selector. The functions of this circuit are: rmits seizure from battery-searching-selectors; kes itself busy and holds the preceding switches ated upon seizure; (3) steps the wipers to the of the dialed line in response to the pulses of st digit to this switch; (4) rotates the wipers dialed line in response to the impulses of the nd digit to this switch; (5) automatically seeks trunk if more than one trunk is provided to the station; (6) automatically rings the called sta- the proper side if it is free, or returns busy the calling line if the called line is busy; (7) ringing and provides reverse battery super- n to the calling line when the called party an- (8) releases completely when the calling party nects; (9) provides for a permanent alarm if itch is seized and a connection is not completed; ovides for a release alarm if the switch does store to normal after the release magnet oper- nd (11) provides Executive Right-of-Way when lead is grounded.

404 (a) Seizure: The preceding switch determines the side of the line on which the called line will be rung. If the called line is to be rung on the + side of the line, the calling line loop is closed across the +L and -L connected to jack points 1 and 2 respectively. If the - side of the line is to be rung, the calling line loop is closed across the -L and +L connected to jack points 3 and 2 respectively.

Battery thru #2C to the C lead marks this switch free and causes the preceding switch to switch thru closing the calling line loop across the +L and -L and closing ground to the C lead. The EC lead is extended thru to this switch from the preceding switch. If the called line is to be rung on the positive (+) side of the line, the calling line loop is closed directly to relay A. If the called line is to be rung on the negative (-) side, the calling line loop is closed in series with the #1 winding of relay K to relay A.

Relay A Operates: (1) opens the incomplete circuit to the release magnet; and (2) closes the circuit to relay B.

Relay C Operates; (1) opens the incomplete impulsing circuit to the rotary magnet and relays E and J; and (2) prepares the impulsing circuit to its #1 winding in multiple with the vertical magnet.

Relay B Operates; (1) closes ground to the C lead to hold the preceding switches operated and to make this switch busy; and (2) prepares the locking circuit to relays K and M.

Relay K Operates; (if the negative line is to be rung); (1) closes the locking circuit to its #2 winding; (2) closes a short circuit to its #1 winding; and (3) reverses the incomplete ringing circuit to the called line.

404 (b) Vertical Stepping: (Relays A, B, C and possibly K operated): Relay A follows the dial pulses over

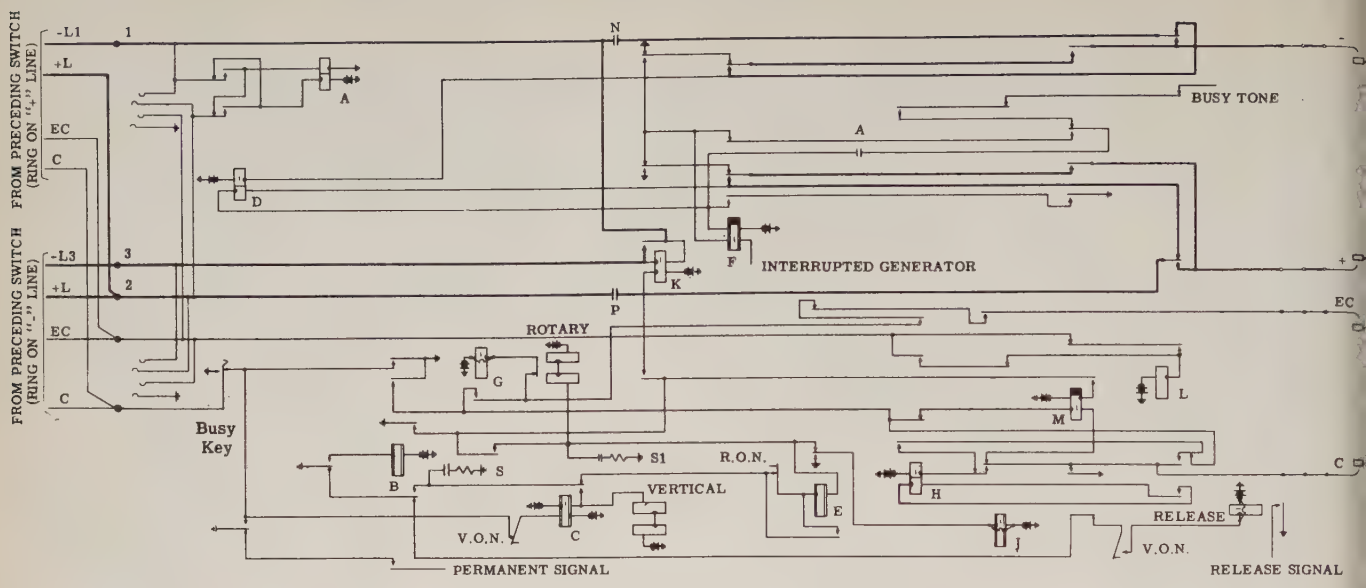



Fig. 13 - Circuit of Connector (Repeated).

the calling line loop, and when at normal, opens the circuit to relay B and closes the circuit to #1C and the vertical magnet in multiple. The vertical magnet operates on each ground pulse received from relay A to raise the shaft and wipers one vertical step. On the first step, the V.O.N. springs operate.

V.O.N. Springs Operate; (1) open the circuit to #1C; and (2) prepare an incomplete circuit to the release magnet.

Relays B and C do not release during a series of impulses since they are made slow-to-release by copper sleeves.

When the last impulse of the first digit to this switch has been received, relay A comes to rest operated, opening the circuit to #1C and closing the circuit to relay B. The wipers are now resting on the dialed level.

Relay C Restores; and transfers the incomplete circuit from #1C and the vertical magnet to relay E in series with the rotary magnet and relay J in multiple.

404 (c) Rotary Stepping: (Relays A, B and possibly K operated) Relay A follows the impulses of the second digit dialed to this switch, and when at normal, opens the circuit to relay B and closes the circuit to relay E in series with relay J connected in multiple with the rotary magnet. Relays E and J operate on the first impulse.

Relay E Operates; (1) closes a multiple circuit to itself and the rotary magnet; (2) transfers relay J from the impulsing circuit to ground at its make contacts; and (3) opens an incomplete circuit to the EC wiper.

Relay J Operates; (1) prepares a circuit to the EC wiper; (2) closes #1H to the C wiper; (3) opens #1M from the C wiper; and (4) opens the incomple busy tone circuit.

Relays B, E and J remain operated during rota pulsing since they are made slow-to-release by co per sleeves. The rotary magnet operates on ea ground pulse received from relay A to step the wipe one rotary step. On the first step the R.O.N. sprin operate.

R.O.N. Springs Operate; and open a multiple circ to relay E and the rotary magnet.

When the last impulse has been received, relay comes to rest operated, opening the circuit to rel E and the rotary magnet. The wipers come to re on the bank contacts associated with the called lin

Relay E Restores; (1) opens the incomplete impu sing circuit to the rotary magnet and itself; (2) ope the circuit to relay J; and (3) prepares the circuit the EC wiper.

Relay J is slow-to-release to permit the testing of t called line for a busy condition before it restore

404 (d) Trunk Hunting (Relays A, B, J and possibly operated): When the called number is assigned to group of consecutive trunks on the same level, t CN and ECN bank contacts of all except the last tru of the group are strapped together to cause automat trunk hunting if the first trunk is busy.

If the first trunk of a called group is busy, the wiper encounters ground on the CN bank contact close the circuit to the #1 winding of relay H. Sin the CN and ECN bank contacts are strapped togethe the EC wiper also encounters ground which closes t circuit to relay G when relay H operates. Relay hasn't yet restored since it is slow-to-release.

H Operates; (1) closes the circuit to relay G round on the EC wiper; (2) prepares its lock- cuit; (3) prepares the circuit to relay L; (4) es the busy tone circuit: and (5) opens the in- te circuit to the #1 winding of relay M.

G Operates; (1) closes its locking circuit; and sses the circuit to relay J and the rotary mag-

tary magnet steps the wipers to the next trunk ns the circuit to relay G.

G Restores; (1) opens its incomplete locking ; and (2) opens the circuits to relay J and the magnet.

tary magnet restores and closes relay G to the er.

runk is tested in the manner described above free one is found or the last trunk is reached, runks are busy. When an all trunks busy con- exists, the wipers are stepped to the last trunk relay G cannot reoperate as the CN and ECN ontacts are not strapped together on this trunk.

e trunk is found, it is seized and rung as ex- l under Sec. 404 (e). If all trunks are busy, the party receives busy tone as explained under 04 (h).

Switching Thru To The Called Line: (Relays and possibly K & H operated:) If trunk hunting en place, relay H is in its operated position wipers are stepped onto the first free trunk. rcuit to relay H is now open as no ground is tered on the CN bank contact of a free trunk.

H Restores (if trunk hunting took place); (1) its incomplete locking circuit; (2) opens part busy tone circuit; (3) prepares the circuit to winding of relay M; and (4) opens part of the to relay L.

momentary delay as a result of its slow-to- e characteristics, relay J restores.

J Restores; (1) opens #1H from the C wiper; ses #1M to the C wiper; (3) opens relay G he EC wiper; (4) opens relay L from the EC and (5) prepares the incomplete busy tone cir-

line is marked by resistance battery on the nk contacts which closes the circuit to the #1 g of relay M, when relay J restores.

M Operates; (1) closes the locking circuit to winding; (2) prepares the locking circuit to the ut-off relay F; (3) completes the ringing cir- the called line thru the #2 winding of relay F; ses ringing current thru condensers A and P to INE to return ringback tone to the calling line; ses ground to the C wiper to make the called line busy; (6) opens the incomplete circuit to the re- lease magnet; and (7) opens the incomplete locking circuit to relay L.

The calling line is now rung on the proper side. Re- lay F does not operate on ringing current since it is slow-to-operate.

404 (f) Answering: (Relays A, B, M and possibly K operated): When the called party answers, a loop circuit is closed across the + and - wipers to close a direct current to the #1 winding of relay F from battery superimposed on generator.

Relay F Operates; (1) closes the locking circuit to its #2 winding; (2) opens the ringing circuit, opening the circuit to its #1 winding; and (3) closes the called line loop to relay D.

Relay D Operates; (1) reverses the battery to the calling line for supervisory purposes; (2) removes ground from the permanent alarm lead; and (3) closes a multiple ground to the C lead.

404 (g) Transmission: (Relays A, B, D, F, M and possibly K operated): Transmission battery is sup- plied to the calling line thru relay A and to the called line thru relay D. Voice currents flow thru conden- sers N and P.

404 (h) Returning Busy Tone For Busy Condition: (Relays A, B, J and possibly K and H operated): When the called line is busy or all trunks of a called group are busy, the calling party receives busy tone as ex- plained below. If the called line is assigned several trunks and all trunks are busy, the wipers are stepped to the last trunk where relay H remains operated from ground on the C wiper. If the called number is assig- ned only one trunk and is busy, ground on the C wiper closes the circuit to relay H.

Relay H Operates (if not already operated): (1) pre- pares its locking circuit; (2) opens the incomplete circuit to the #1 winding of relay M; (3) closes relay G to the EC wiper; (4) prepares the circuit of relay L to the EC lead; and (5) prepares the busy tone cir- cuit.

After a momentary delay, relay J restores.

Relay J Restores; (1) opens relay G from the EC wiper; (2) transfers the #1 winding of relay H to the holding circuit; (3) prepares the incomplete circuit to the #1 winding of relay M; (4) closes busy tone thru condensers A and P to +L returning busy tone to the calling party; and (5) closes relay L to the EC lead.

404 (i) Executive Right-of-way: (Relays A, B, H and possibly K operated.) The line equipment of certain stations in the telephone system may be specially equipped to cause the connector to switch thru on a busy line or trunk. In this case, ground is closed to the EC lead to cause relay L to operate.

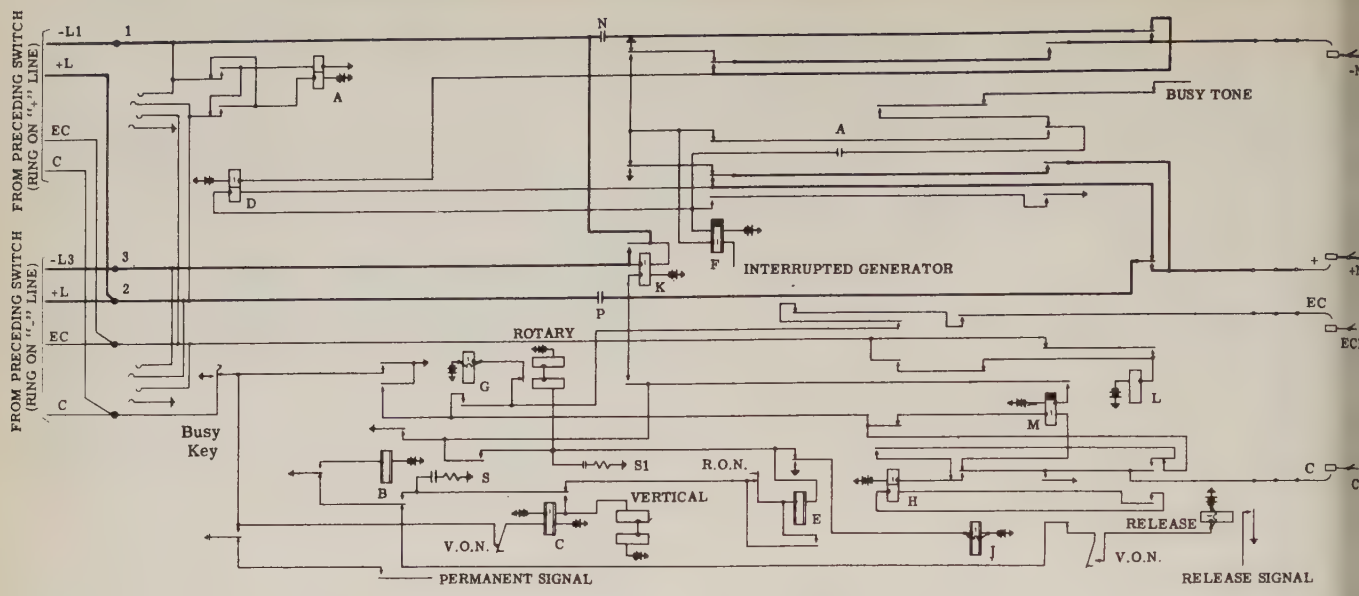



Fig. 13 - Circuit of Connector (Repeated).

Relay L Operates; (1) closes its locking circuit to the EC lead; (2) transfers the #1 winding of relay H from locking ground at relay B to ground on the C wiper; (3) closes a short circuit to the #2 winding of relay C, making it slow-to-release; (4) opens the incomplete circuit to relay D; (5) closes the +L and -L thru condensers P and N to the + and - wipers respectively; and (6) removes busy tone from the calling line.

The calling station now has a transmission circuit thru to the called line over which the calling party may listen and talk to the called party. Transmission battery is supplied to the calling line thru relay A and to the called party by an associated circuit. Voice currents flow thru the N and P condensers.

If the calling party desires, he may request that the previous connection be released. When this is done, ground is removed from the CN bank contact and replaced by resistance battery, opening the circuit to the #1 winding of relay H. Relay H is now made slow-to-release by its short circuited #2 winding to allow the previous connection to the called line to release completely.

Relay H restores; (1) closes the circuit to the #1 winding of relay M; (2) opens its incomplete locking circuit; (3) opens the incomplete busy tone circuit; (4) opens the incomplete circuit to relay G; and (5) opens the operating circuit to relay L.

Relay M Operates; (1) closes the locking circuit to its #2 winding; (2) closes ground to the C wiper to make the called line busy; (3) opens the incomplete circuit to the release magnet; (4) opens the locking circuit to relay L; (5) prepares the locking circuit to the #2 winding of relay F; (6) closes ringing current to the called line thru the #2 winding of relay F; and (7) prepares a ringing current circuit thru condensers A and P to +L to return ring-back tone to the calling line.

Relay L Restores; (1) opens its incomplete lockin circuit; (2) prepares the locking circuit to the # winding of relay H; (3) opens the short circuit to th #2 winding of relay H; (4) opens condensers P and from the + and - wipers; (5) prepares the circuit t relay D; (6) prepares the busy tone circuit; and ( closes the ring-back tone circuit to the calling lin

If both of the parties to the former connection, dis connect, this circuit will begin ringing automaticall on the line called by the executive as described i Sec. 404 (e). The connection will be completed a described in Sec. 404 (f) when the call is answered

If the executive is calling the called party of th former connection and if only the calling party of th former connection disconnects, ringing will be omit ted and this circuit will connect to the line, called b the executive, immediately as described in Sectio 404 (i).

If the executive is calling the calling party of th former connection and if only the called party of th former connection disconnects, the former connectio will not be completely released and a three way con nection is possible. Ringing will start if the execu tive holds the connection after the other party dis connects.

Transmission and releasing is normal as describe below.

404 (j) Release:

404 (k) Release from a Completed Call:
(Relays A, B, D, F, M and possibly K operated):

(A) Calling Party Disconnects First: The loop circui is opened to relay A, whereupon -

Relay A Restores; (1) opens the circuit to relay B and (2) prepares the circuit to the release magnet

B Restores; (1) prepares further the circuit to release magnet; (2) opens the incomplete circuit permanent alarm lead; (3) removes a multiple ed from the C lead; (4) opens the locking circuit #1 winding of relay M; and (5) opens the lock- ircuit to the #2 winding of relay K (if operated).

K Restores (if operated); (1) opens its incom- locking circuit; (2) removes the short circuit the #2 winding of relay K; and (3) reverses the plete ringing circuit.

M Restores; (1) removes ground from the C r making the called line free; (2) closes the t to the release magnet; (3) opens the locking it to the #2 winding of relay F; (4) opens the ts to the + and - wipers, opening the called line o relay D; (5) opens the incomplete ring-back ircuit; and (6) prepares the busy tone circuit.

D Restores; (1) removes ground from the C o release the preceding switches; (2) prepares ound circuit to the permanent alarm lead; and verses battery to the +L and -L.

F Restores; (1) opens the incomplete circuit ay D; (2) prepares the ringing circuit; and (3) the incomplete locking circuit to its #2 winding.

elease magnet operates, closes ground to the e alarm lead; and releases the shaft and wipers return to normal and restore the R.O.N. and . springs. Ground on the release alarm lead s an alarm lamp to light to signal the attendant wipers fail to restore to normal.

. Springs Restore and prepare the circuits to E and J and the rotary magnet.

. Springs Restore; (1) close the #2 winding of C to the C lead; and (2) open the circuit to lease magnet.

elease magnet restores and removes ground he release alarm lead. Battery thru the #2 g of relay C now makes this switch free.

alled Party Disconnects First: When the called disconnects first, the loop circuit is opened to D, whereupon:

D Restores; (1) reverses battery to the calling (2) removes a multiple ground from the C lead; 3) closes ground to the permanent alarm lead.

elease is now completed as explained under Sec. 0) (A) when the calling party disconnects, except D is already restored and relay B removes d from the C lead and the permanent alarm lead t restores.

Release from Busy: (Relays A, B, H and pos- K operated): When the calling party disconnects receiving busy tone, the line loop is opened to A, whereupon:

Relay A Restores; (1) opens the circuit to relay B; and (2) prepares the circuit to the release magnet.

Relay B Restores; (1) closes the circuit to the release magnet; (2) removes ground from the C lead to release the preceding switches; (3) opens the locking circuit to the #1 winding of relay H; and (4) opens the locking circuit to the #2 winding of relay K (if operated).

Relay H Restores; (1) opens the busy tone circuit to the -line; (2) opens its incomplete locking circuit; (3) opens the incomplete circuit to relay L; and (4) opens the incomplete circuit to relay G.

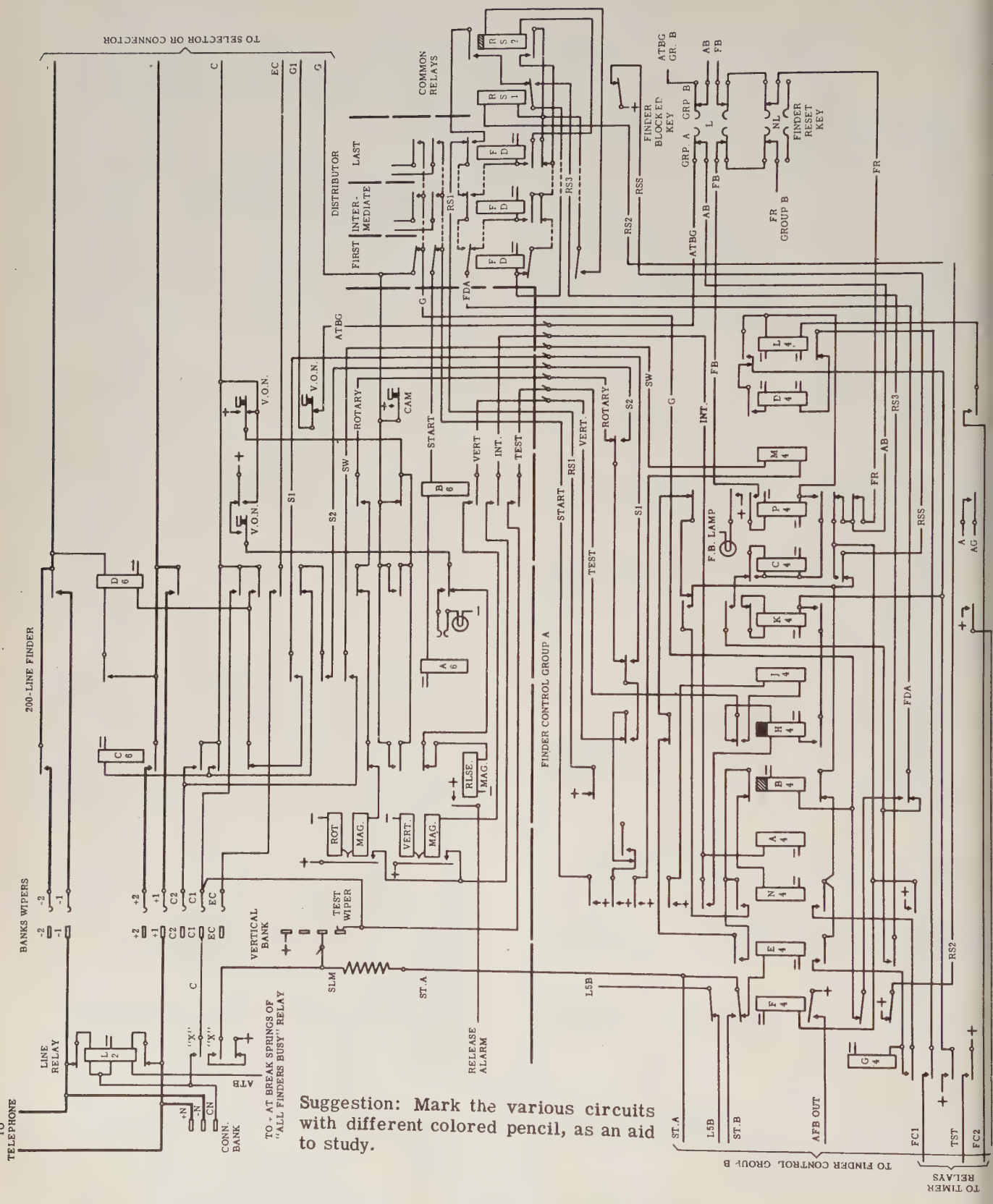
Relay K Restores (if operated); (1) opens the short circuit to its #1 winding; (2) opens the incomplete locking circuit to its #2 winding; and (3) reverses the incomplete ringing circuit.

The release magnet operates, closes ground to the release alarm lead to give an alarm if the connector fails to release, and releases the shaft and wipers. The shaft and wipers return to normal and restore the R.O.N. and V.O.N. springs.
R.O.N. Springs Restore and prepare the circuits to relays E and J and the rotary magnet.
V.O.N. Springs Restore; (1) close the #2 winding of relay C to the C lead; and (2) open the circuit to the release magnet.
The release magnet restores and removes ground from the release alarm lead. Battery thru the #2 winding of relay C to the C lead makes this switch free.

404 (m) Permanent Alarm: When this connector is seized, relay B operates and closes ground to the permanent alarm lead to light a permanent alarm lamp which is extinguished when the called party answers if the connection is completed. This is done by the operation of relay D. If the connection is not completed to the called line and the calling party does not disconnect, the permanent lamp continues to glow to signal the attendant.

404 (n) Busy Key: The busy key provides a convenient means of making this circuit busy when desired. When operated this key removes battery thru the #2 winding of relay C from the C lead and replaces it with direct ground to make this connector busy at the preceding switches.

404 (o) Spark Suppression: Condenser S connected in series with a resistance from ground to a make spring of relay C prevents excessive sparking at contacts of relay A during impulsing.
Condenser S1 connected in series with a resistance from ground to one side of the rotary magnet winding prevents excessive sparking at contacts of relay A during dialing and contacts of relay G during trunk hunting.
The non-inductive resistance connected across the #1 windings of relays G and J and the release magnet prevents excessive sparking at the contacts which open these circuits.




Suggestion: Mark the various circuits with different colored pencil, as an aid to study.

Fig. 14 - Circuit of 200-Line Finder Switch

Figure 14 also shows the finder control relays associated with the "group A" finders, an "all relay" distributor and a single "combined line and cut-off relay." The functions of this circuit are: (1) To operate the line relay from the subscribers loop; (2) start the finder which has been preselected; (3) elevates the wipers to the level on which the subscriber's line appears; (4) rotate the wipers to the contacts to which the subscriber's line is connected; (5) extend the subscriber's line to the succeeding switch. a. Operate the line relay completely; b. make the subscriber's line busy to other calls; (6) operate the distributor to select the next idle finder for the succeeding call; releases finder upon completion of call; (8) rotates the wipers of the finder to the eleventh rotary position when the finder fails to find the subscriber's line and cause the distributor to allot the next idle finder to the call; (9) release the finder and transfer the call to the partner group when the line is not found within a specified time; (10) transfer to the partner group when there is an A.T.B. (all trunks busy) condition.

The finders in this system are divided into two groups, each group having control and distributor relays.

Two hundred lines are connected onto the finder banks. The first fifty lines of each hundred group are connected on levels one to five inclusive of group (A), and on levels ten to six of group (B). The second fifty lines of each hundred group are connected to levels ten to six inclusive of the group A finders, and to levels one to five of the group B finders.

In the following explanation, a call will be traced thru the 100 group of the group A finders. Only one line circuit is shown, but the explanation would be the same for any one of the two hundred to be served by the line finder.

Relays F4, RS1, and one of the FD relays are normally operated.

405 (a) Finding the Calling Line:

(A) Seizure: When the calling subscriber initiates a call, the loop is closed to line relay L2 from ground at springs of the all finders busy relay. The line relay, which is a two-step relay, closes its "X" contacts only.

Line Relay L2 operates its "X" contacts only: (1) places resistance battery on the C lead to the finder banks to mark this calling line; and (2) places ground upon the SLM lead.

Remembering that this is a 200-line finder, and assuming that the calling subscriber's line is in the 100 group, the battery placed on the C lead



Ground upon the SLM lead places direct ground upon the vertical banks of the finder to mark the level in which this calling line will be found. The same ground, through 2000 ohms, closes a circuit to the E4 relay by way of the ST. A lead.

Relay E4 operates; (1) prepares a circuit to the FD (first) relay; (2) closes a circuit to relay G4; and (3) closes a circuit to relay N4.

Relay G4 operates; (1) prepares its holding circuit; (2) closes 1200 ohm battery to the FC1 lead thru the lower winding of relay D4; (3) closes ground to the TST lead to start the timer circuit; and (4) closes the circuit to relay K4.

Relay N4 operates; (1) places ground upon the vertical lead; (2) places ground upon the start lead; (3) prepares a circuit to relay M4; (4) prepares a circuit to relay J4; (5) prepares a circuit to relays A4 and H4; (6) closes the holding circuit for relay G4; (7) closes a multiple ground to relay F4; and (8) prepares its own holding circuit.

Relay K4 operates; (1) prepares a circuit to transfer the next call to the next finder; (2) opens its shorted winding; (3) prepares the holding circuit for relay H-4; (4) completes the holding circuit of relay N4; (5) opens the operating circuit to relay N4; and (6) grounds the L5AG lead.

Ground on the L5AG lead grounds the fifth level of the group A finder banks, so that those finders will not search above the fifth level.

(B) Vertical Hunting (Relays L2, G4, E4, N4, and K4 operated): Ground on the start lead of the finders closes a circuit to relays A6 and B6 of the finder that corresponds with the particular FD relay that is operated.

Relay A6 operates; (1) prepares the circuit to relay M4; (2) closes 500 N.I. resistance (upper winding of D6) across the "-" and "+" trunk; (3) prepares the circuit to the D6 relay; and (4) prepares the circuit to relay C6.

Relay B6 operates; (1) prepares the operating circuit of relay H4; (2) prepares the holding circuit for relay A4; (3) opens the bridge between the G and C leads removing (-) battery on the G lead from the C lead; (4) opens the incomplete circuit to the release magnet; (5) places ground upon the C lead; (6) prepares the circuit to the rotary magnet; (7) prepares the operating circuit of relay A4; and (8) completes a circuit to the vertical magnet.

The resistance across the "-" and "+" trunk pre-seizes the succeeding switch.

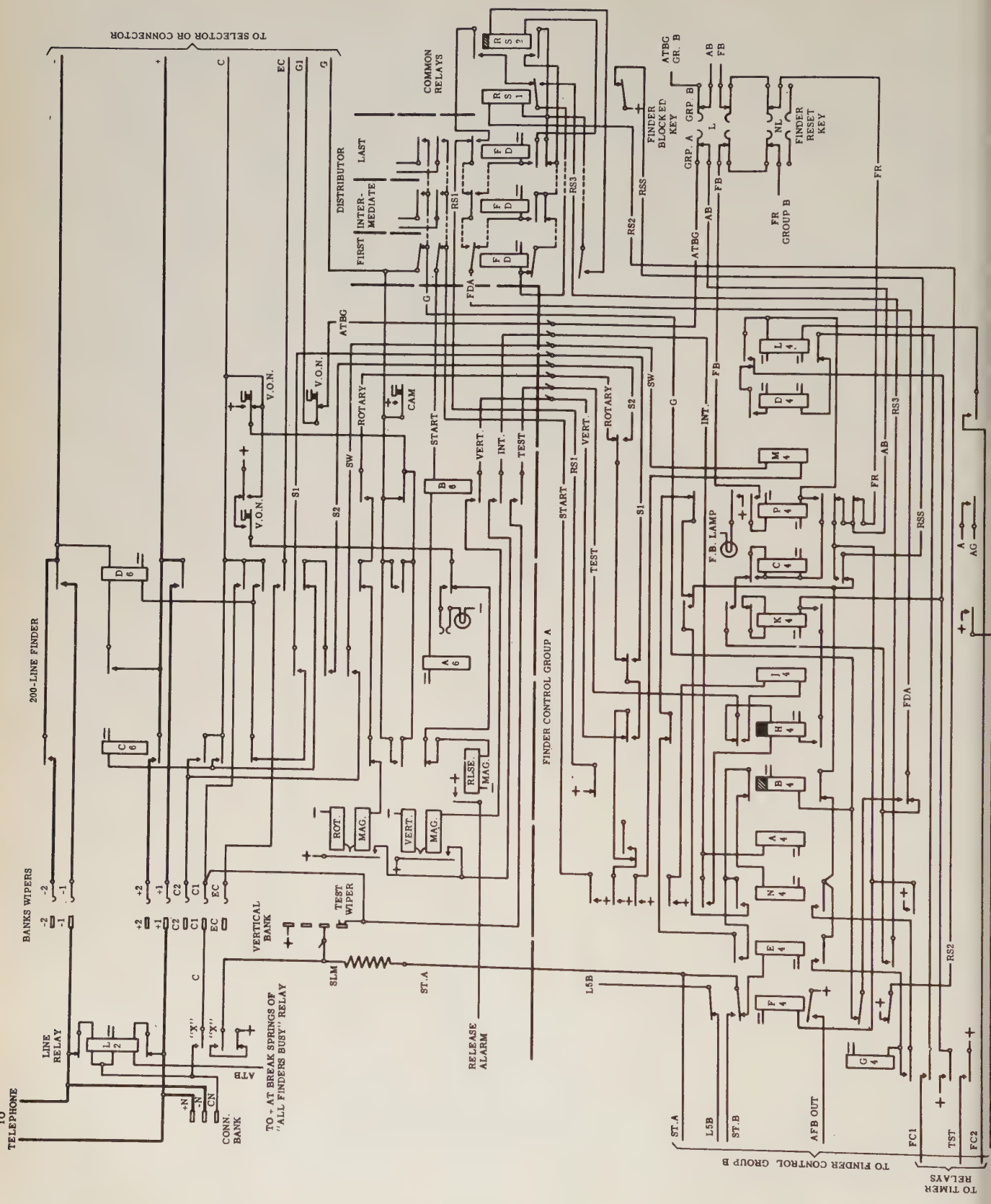



Fig. 14 - Circuit of 200-Line Finder Switch (Repeated).

The V.O.N. springs operate, preparing ground for the G lead, opening the G1 lead preparing the circuit to the release magnet.

Opening the G1 lead removes a multiple ground from the ATBG (all trunks busy ground) lead and from relay F4.

Relay A4 operates and opens the circuit to the vertical magnet.

Vertical Magnet releases and opens the circuit to relay A4.

Relay A4 releases and closes the circuit to the vertical magnet.

The vertical magnet, and the A4 relay continue this cycle, stepping the finder until the test wiper finds ground upon the vertical bank.

When the test wiper finds the grounded level, ground will be returned over the test lead. Ground upon the test lead closes a circuit to the #1 winding of relay H4 in series with relay A4.

Relay H4 operates its "X" contacts and closes its holding circuit.

Relay A4 operates and opens the circuit to the vertical magnet.

Relay H4 operates completely; (1) opens further the circuit to the vertical magnet; (2) prepares the circuit to the rotary magnet; (3) opens its own operating circuit and the holding circuit to relay A4; (4) prepares a circuit to the J4 relay; and (5) opens further the operating circuit of relay N4.

Vertical Magnet releases and opens the circuit to relay A4.

Relay A4 releases and closes the circuit to the rotary magnet.

(C) Rotary Hunting (Relays L2, E4, G4, H4, A6, B6, N4 and V.O.N. operated): The finder hunts for the resistance battery placed upon the C contact of the calling party by the L2 relay.

When its circuit is closed by the A4 relay, the rotary magnet operates.

Rotary Magnet operates; (1) rotates the wipers to the first contact; and (2) closes the circuit to the A4 relay over the interrupter lead.

Relay A4 operates and opens the circuit to the rotary magnet.

Rotary Magnet releases and opens the circuit to the A4 relay.

Relay A4 releases and recloses the circuit to the rotary magnet.

contacts are marked by resistance battery on the C contact.

When the rotary magnet steps the wipers to the marked contact, a circuit is closed to A4 relay which operates to open the circuit to the rotary magnet. Battery on the C lead completes a circuit to the J4 relay over the test lead (assuming the call originated from a 100 group subscriber).

If the call had originated from a 200 group subscriber, the C lead would have been connected to bank contact C2, and battery thereon would have passed by way of wiper C2 to relay M4. Relay M4 would then perform the same functions as relay J4 (see below), except that it would prepare the circuited to relay C6 over the S2 lead instead of to relay D6 over the S1 lead.

Relay J4 operates; (1) opens the rotary magnet circuit; and (2) prepares the circuit to relay D6 over the S1 lead.

Note that the circuit to the #1 winding of relay L2 is now in series with relay J4.

Relay L2 operates completely; (1) opens its operating circuit; (2) removes an attachment from across the lines; and (3) removes ground from SLM lead and relay E4.

Relay E4 releases; (1) opens the operating circuit of relay G4; and (2) opens the operating circuit of relay N4.

When the rotary magnet releases, the circuit is opened to relay A4.

Relay A4 releases and closes the circuit to relay D6.

If the call had originated from a 200 group subscriber, relay A4 would have closed the circuit to relay C6 instead of relay D6. Relay C6 would then have performed functions similar to those of relay D6 (see below), except that it would close the EC lead to the succeeding switch.

(D) Switch Through (Relays L2, N4, H4, K4, J4, A6, B6, and G4 operated) Relay D6 operates from ground on the S1 lead.

Relay D6 operates; (1) switches the lines through from the calling station to the succeeding switch; (2) closes the C lead to place direct ground upon the L2 relay and to busy this subscriber's equipment; (3) closes the EC lead to the succeeding switch; (4) closes its own holding circuit onto the C lead; (5) opens the incomplete circuit to relay C6; (6) places ground on the G lead to cause the distributor to select the next idle finder switch and to busy this finder; (7) opens the incomplete release circuit; and (8) opens the incomplete circuit to the rotary magnet.

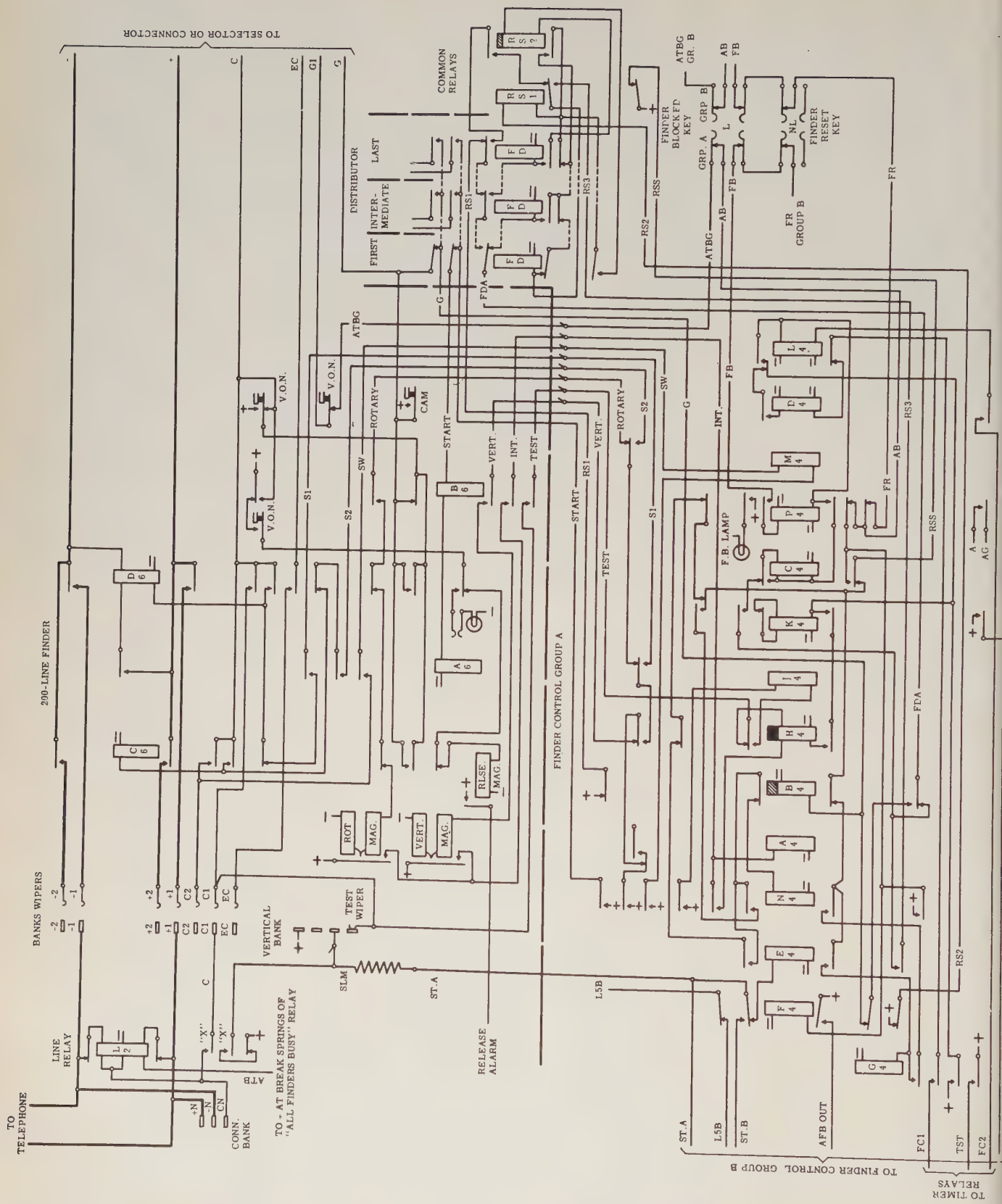



Fig. 14 - Circuit of 200-Line Finder Switch (Repeated).

cuit to relay B4.

Relay B4 operates; (1) closes the circuit to the next FD relay in the chain; (2) opens the circuit to relay G4; and (3) opens the circuit to relay N4.

The (second) FD relay operates (assuming the first already operated).

Relay FD (second) operates; (1) closes its own locking circuit in series with relay RS1; (2) prepares the G lead to the second finder; (3) prepares the start lead to the second finder; (4) prepares the circuit to the next FD relay in the chain; and (5) opens the holding circuit of the preceding FD relay.

Relay N4 releases; (1) removes ground from the SW lead in series with relay M4; (2) opens the circuit to relays A6 and B6 over the start lead; (3) opens the circuit to relay J4; (4) opens the incomplete circuit of relay A4 through the #1 winding of relay H4; (5) opens the holding circuit of relay G4; (6) removes a multiple ground from relay F4; (7) opens further its locking circuit; and (8) opens the operating circuit to relay D6.

Relay G4 restores; (1) opens its incomplete holding circuit; (2) opens the FC1 lead to the timer relays; (3) opens the TST lead to the timer relays; (4) opens the circuit to relay K4; and (5) opens the holding circiot of relay H4.

Relay FD (first) releases; (1) opens the G lead and the circuit to relay B4; (2) opens the operating circuit of relay FD (second); (3) opens the start lead; (4) prepares the circuit to relay FD (third); (5) opens further its locking circuit; and (6) prepares a circuit to relay RS2.

Relay A6 releases; (1) removes the pre-seizing resistance from across the lines; and (2) opens further the operating circuit of relay D6.

Relay B6 restores; (1) closes ground to the G lead; (2) removes a multiple ground from the C lead (the other ground is supplied by the associated selector or connector); (3) prepares the circuit to the release magnet; and (4) opens various incomplete circuits.

Relay J4 releases; as do relays K4, H4, and B4.

The finder control circuit (Fig. 4) is now at normal and ready for the next call which will be found by the second finder, provided it is not busy.

If the second finder is busy, ground is maintained on the G lead to the second FD relay.

When the second FD relay operates, the circuit is prepared to the third FD relay and the circuit is opened to the first FD relay. The first FD relay in releasing, completes a circuit to the third FD relay from ground on the G lead to the second FD relay. The third FD relay will operate and allot the call to the third finder.

If the third finder were busy, the search for an idle finder continues in a manner similar to that described above.

(G) Distributor Operation When Last FD Operates: When the next to the last finder becomes busy, the circuit is closed to the last FD relay which operates.

Relay FD (last) operates; (1) closes its own locking circuit in series with relays RS1 and RS2; (2) prepares the G and start leads to the last finder; (3) prepares the circuit to relay FD (first); and (4) opens the circuit to the next to the last FD relay.

The next to the last FD relay will release.

Relay RS2 operates; (1) prepares the operating circuit to relay FD (first); and (2) prepares the locking circuit to relay FD (first).

When another call is initiated, the last finder finds the line and places ground on the G lead to operate the FD (first) relay.

Relay FD (first) operates; (1) closes its own locking circuit in series with relay RS1; (2) prepares the first finder for the next call; (3) opens its operating circuit; (4) prepares a circuit to the FD (second) relay; and (5) opens the circuit to relays FD (last) and RS2.

Relay FD (last) releases and closes a multiple circuit to relay RS1.

Relay RS2 Releases; (1) opens the operating circuit to relay FD (first); and (2) opens a multiple circuit to relay RS1.

(H) Release (Relays L2, D6 and V.O.N. Springs Operated): When the calling party releases, the loop is opened to the connector switch which removes ground from the C lead. The removal of ground from the C lead opens the circuit to relays L2 and D6.

Relay L2 releases and restores the line equipment to normal.

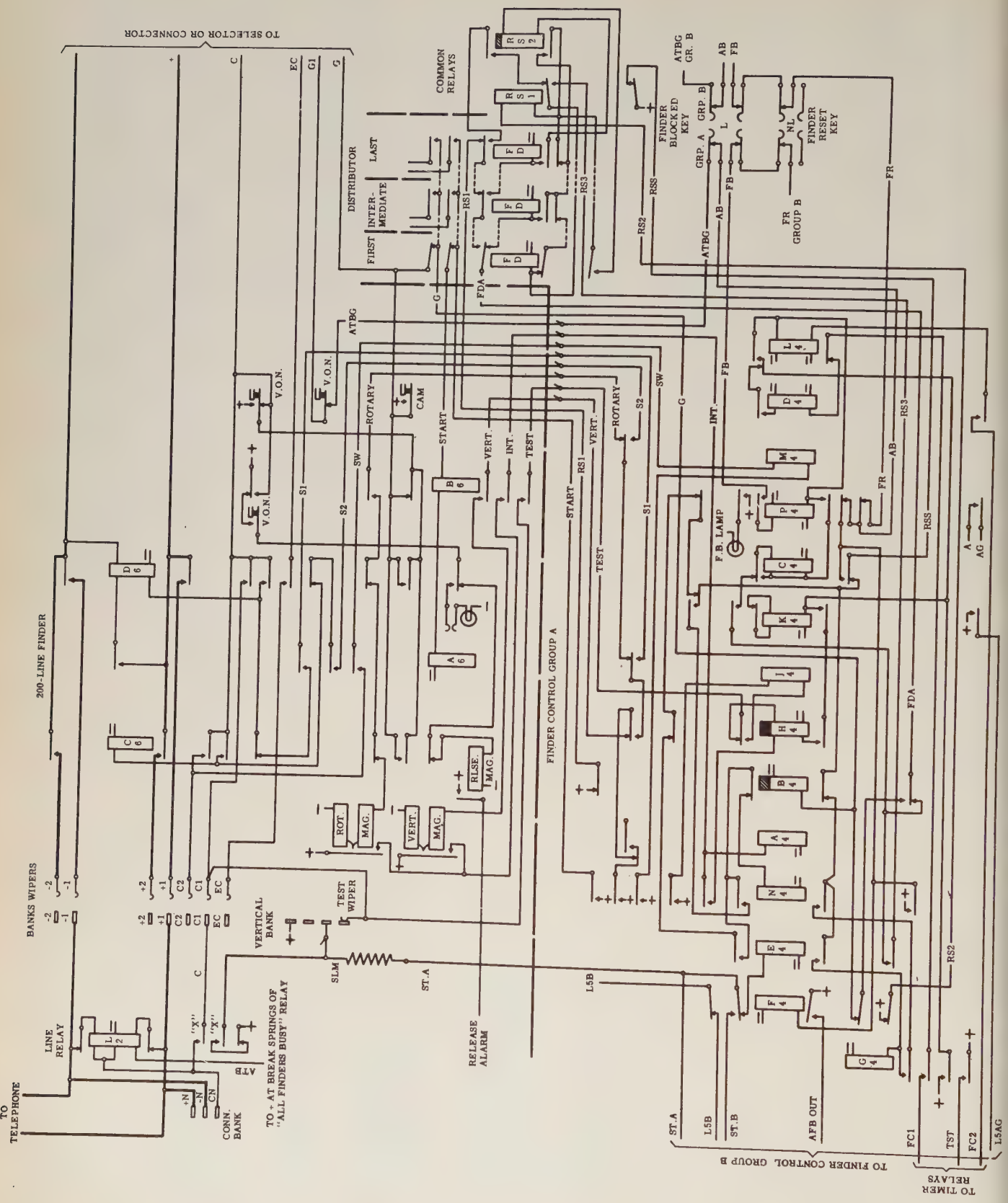



Fig. 14 - Circuit of 200-Line Finder Switch (Repeated).

Ground is maintained upon the G lead so that this switch cannot be seized during release.

Release Magnet operates; (1) closes ground onto the release alarm lead; and (2) releases the finder shaft and wipers.

When the shaft and wipers restore to normal, the V.O.N. springs are released.

V.O.N. springs release; (1) remove ground from the G lead; (2) open the release magnet circuit; (3) close the G1 lead; and (4) connect the C lead to the G lead.

Release Magnet releases and removes ground from the release alarm lead. This finder is now ready for re-use.

(I) Transferring Future Calls of Group A to Group B if all Finders of Group A Are Busy: Normally relay RS1, relay F4 and one of the FD relays are operated.

The FD relay and the RS1 relay, which operate in series, are held operated from ground at springs of the F4 relay. The F4 relay receives a multiple source of ground from the ATBG lead.

The ATBG lead is multipled to all finders associated with this finder group. The succeeding switch, when idle, completes a circuit from the ATBG lead to the G1 lead of the finder associated with it. As soon as a finder begins to search for a line, ground which is removed from the G1 lead, removes a multiple ground from the ATBG lead. When all finders but one are busy, the F4 relay is held operated by one ground on the ATBG lead. When the remaining finder begins to search for a line, all grounds are removed from the ATBG lead, F4 does not release because it is held operated from ground at springs of relay N4.

When the line has been located, relay N4 is released and the circuit is opened to relay F4.

Relay F4 releases; (1) opens the ST.A lead from relay E4; (2) closes the ST.A lead to the ST.B lead; (3) closes ground to the AFB out lead; (4) opens the circuit to relay RS1, and (5) opens the circuit of the L5B lead.

Calls which are normally handled by the Group A place ground on the ST.A lead which being connected to ST.B causes Group B to search for the call.

Relay RS1 releases and, when any one of the finders of group A become idle, ground is placed upon the ATBG lead closing the circuit to relay F4.

Relay F4 operates; (1) opens ST.A from ST.B; (2) closes the ST.A lead to relay E4; (3) removes ground from the AFB out lead; (4) prepares a circuit to relay RS1; and (5) recloses the L5B lead.

All of the FD relays were released when the group transfer occurred.

When a call is initiated, the circuit is closed to relay E4 which operates closing the circuit to relay FD (first) from ground at springs of relay B4.

The (first) finder is allotted to this call, if it is free, but if it is busy, the distributor will operate as explained under Sec. 405 (a) (F) until an idle finder is found.

(J) Failure of Vertical or Rotary Stepping (Relays L2, E4, N4, K4, A6, B6 and G4 operated):

(J1) If a Finder Is Free In Group B: If the finder allotted to a call is defective and will not step, a short time elapses after which a ground pulse is sent over the FC1 lead from the timer relays, closing the circuit to relay D4.

Relay D4 operates; (1) closes its holding circuit; and (2) prepares the circuit from the FC2 lead to relay L4.

After another interval, a ground pulse will be sent over the FC2 lead from the timer relays, closing the circuit to relay L4.

Relay L4 operates; (1) closes its own holding circuit; (2) opens the circuits to relay D4; (3) closes the circuit to relay P4.

Relay D4 restores and opens the operating circuit to relay L4.

Relay P4 operates; (1) closes the circuit of the F.B. lamp to show that a finder in Group A is blocked; (2) closes the circuit to the #2 winding of relay C4; (3) closes a call transfer circuit thru the #1 winding of relay C4 opposing the #2 winding and finding battery at the next FD relay after the one for the blocked finder; (4) closes its holding circuit over the FB lead thru a contact at relay P4 of group B to ground on the ATBG lead of group B; (5) opens the circuit from the ATBG lead of group A removing a multiple ground from relay F4; (6) opens the incomplete holding circuit to the P4 relay of group B over the FR lead

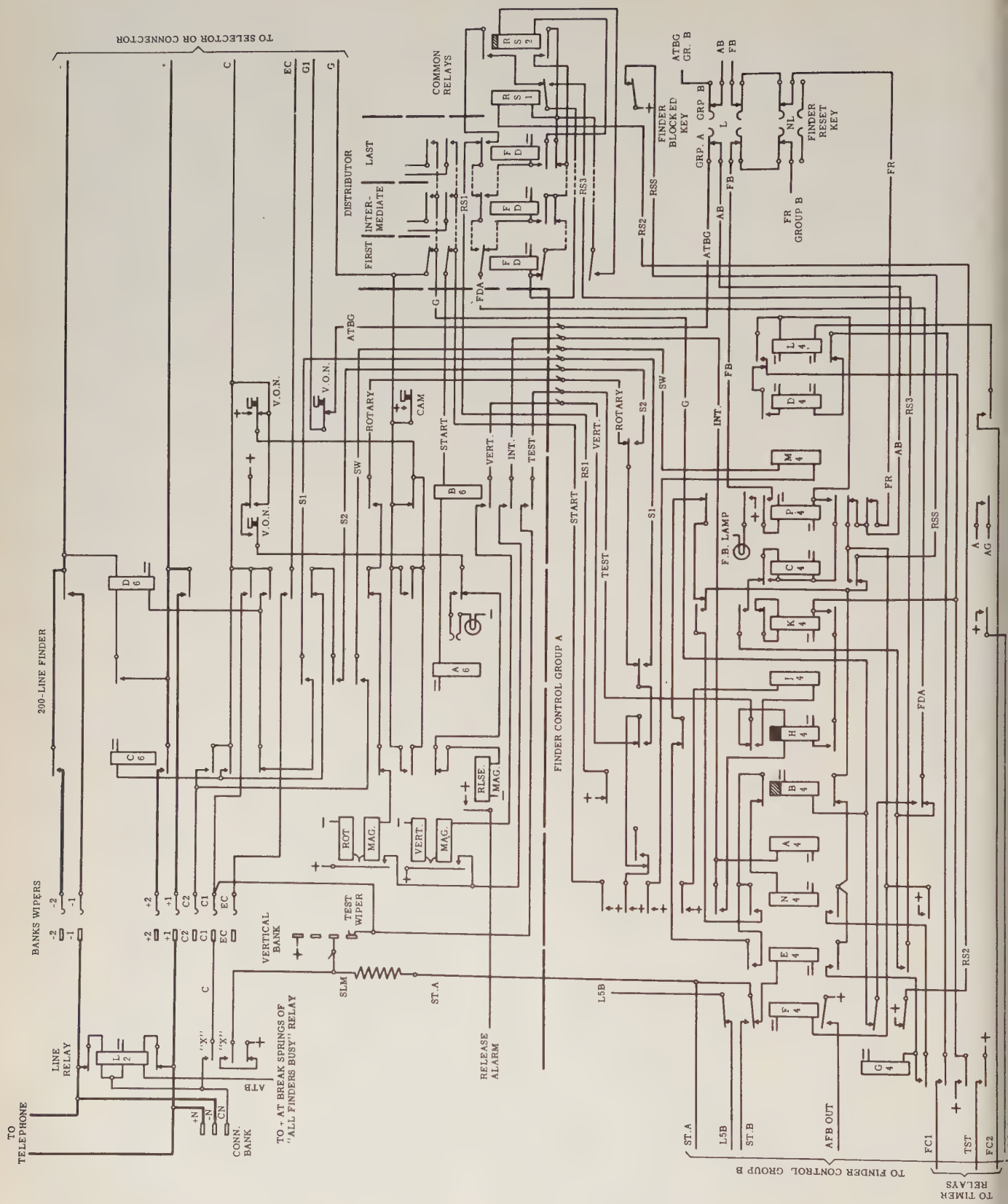



Fig. 14 - Circuit of 200-Line Finder Switch (Repeated).

call to relay F4.

Relay C4 will not operate because its windings are opposing but the circuit to relay FD (second) is closed thru the #1 winding of relay C4.

Relay FD (second) operates; (1) closes its holding circuit; (2) prepares the start and G leads to the second finder; (3) prepares the circuit to the FD (third) relay; and (4) opens the circuit to relay FD (first).

When the holding circuit to relay FD (second) is closed 200 ohm ground is placed on the inside terminal of the #1 winding of relay C4, shunting that winding to permit relay C4 to operate on its #2 winding.

Relay C4 operates; (1) opens the call transfer to relay FD; (2) closes a shunt circuit to its #1 winding; (3) closes a multiple circuit to relay F4; and (4) opens the circuits to relays N4 and G4.

Relay FD (first) restores; (1) opens the start and G leads to the first finder; (2) opens the starting circuit to FD (second); (3) prepares the starting circuit to FD (third); (4) opens its incomplete holding circuit; and (5) prepares the circuit to relay RS2.

Relay N4 restores; (1) opens the stepping incomplete circuit to the finder; (2) opens the circuit to relays A6 and B6 over the start lead; and (3) opens a multiple circuit to relay F4.

Relay G4 restores; (1) opens the TST lead to stop the timer relays; and (2) opens the holding circuit to relays K4, L4 and C4.

Relay L4 restores; as do relays K4 and C4, the latter opens the circuit to relay F4.

Relay F4 restores and transfers all calls to the group B finders.

Relay F4 will remain unoperated as long as relay P4 remains operated and holds the circuit to relay F4 open.

The blocked finder is the one associated with the FD relay preceding the FD relay which is operated.

The attendant seeing the blocked finder supervision should determine which finder is defective and then operate the finder reset key to route calls to the group A finders again.

The finder reset key when operated, opens the circuit to relay P4.

Relay P4 restores and closes the circuit to relay E4.

The defective finder should then be repaired or removed from the jack to prevent further blocking.

(J2) If All Finders Are Busy In Group A: If a finder should fail to step, relays D4 and L4 operate as explained under Sec. 405 (a) (J1) with the following exception:

Since all finders of group B are busy, the holding circuit for relay P4 is opened by relay G4 at the same time as the circuit to relays L4,K4 and C4.

Relay P4 restoring recloses the circuit to relay F4 before it restores after its circuit is opened by the restoring of relay C4.

The circuit is now prepared to route the call to the next finder without the finder reset key being operated.

The finder next in line now searches for the call because the defective finder has been eliminated.

(K) Failure of the Finder to Find a Line (Relays E4, N4, H4, K4, A6, B6 and G4 operated): If a finder fails to find the line, it will step vertically until direct ground over the L5AG lead from relay K4 is encountered at the fifth level. The switch will then rotate automatically until the eleventh bank contact is reached. When the eleventh contact is reached the cam springs are operated which place ground upon the G lead. Ground on the G lead causes the distributor relays to allot the next finder to the call, and this finder will release.

405 (b) Calls to The Subscriber: On calls to the subscriber the connector places ground on the CN lead of the called party's bank contacts. Ground on the CN lead operates the relay L2 completely. When L2 operates completely, attachments are removed from the line circuit and the starting circuit is opened to prevent false operation of the finder. Ground on the CN lead makes this line busy to all other calls.

405 (c) Executive Right-of-Way Service: For those stations requiring executive right-of-way service, the EC bank contact of the finder is strapped to ground to cause the connector associated with the finder to connect to a busy line.

405 (d) Start And Level Marking Circuit: The first 50 subscribers of each hundred group are connected so that the first 10 subscribers have connections to the first vertical bank contact of group A. The second 10 subscribers have connections to the second vertical bank contact of group B. The remainder of the first 50 connections are similar.

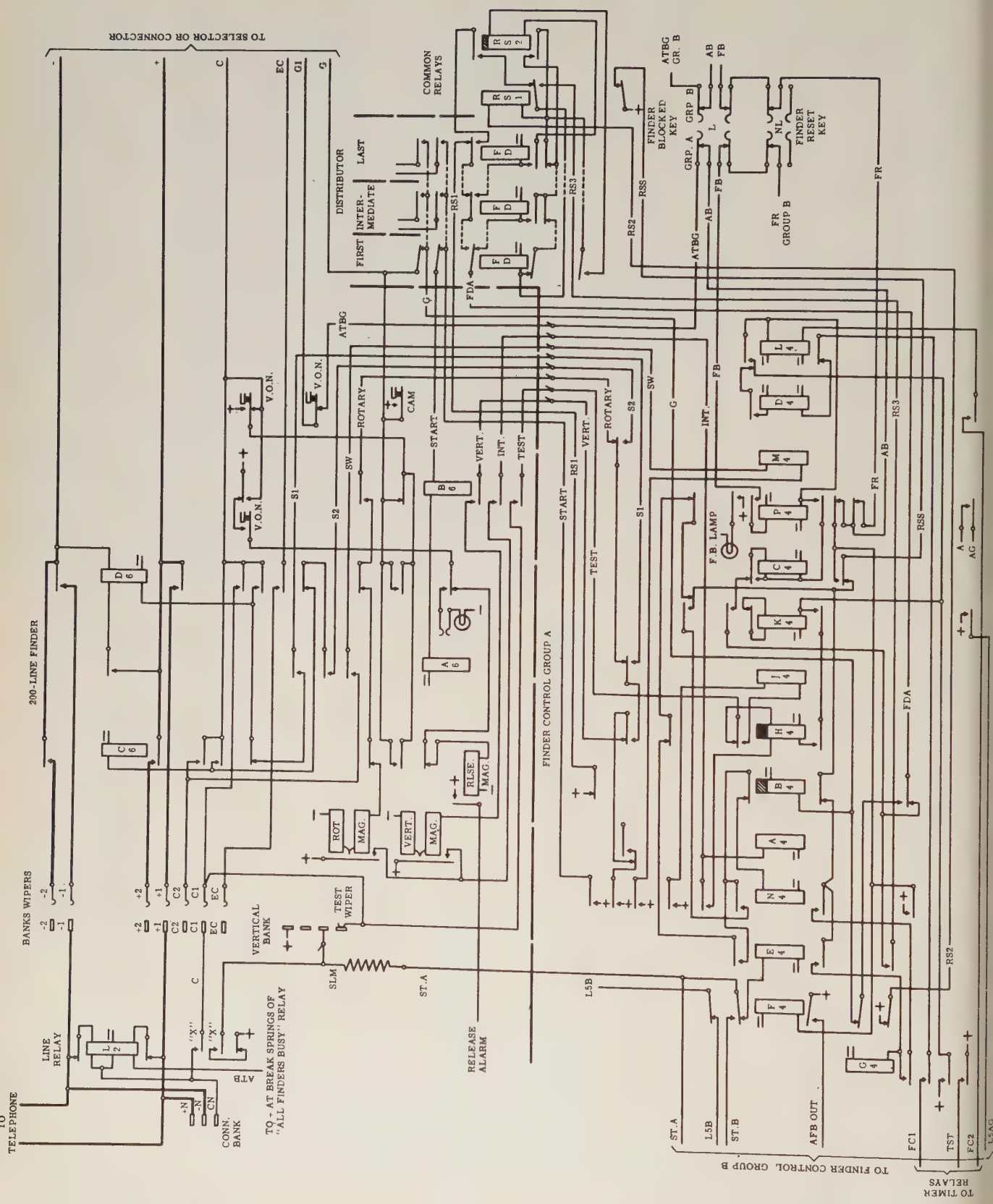



Fig. 14 - Circuit of 200-Line Finder Switch (Repeated).

bank contact of group B. The ninth group of 10 subscribers have connections to the second vertical bank contact of group B and the ninth vertical bank contact of group A. The remainder of the last 50 connections are similar.

This method of making connection allows one group of finders to search for the first 50 subscriber lines and the other group to search for the second 50 lines, with both groups searching normally over the first five levels. Both groups of finders have access to the entire hundred lines under abnormal conditions.

Normally, when a finder operates, it places ground on the fifth level so that it cannot search above that level. When the partner group has an A.T.B. condition that ground is removed so that the other group can find all calls.

The "0" level is grounded in all cases so that the finder will always stop vertical motion when that level is reached. With that level grounded, the finder will not continue to attempt vertical stepping when a line cannot be found.

The 2000-ohm resistors are for isolating the grounds on the SLM lead. With these resistors, ground on the fourth level, for example, will not permit the finder to stop on the first level.

405 (e) All Finders Busy: When both groups of finders have an A.T.B. condition, the F relays in both finder control circuits will be released. The AFB leads being closed, complete the circuit to relay FB (not shown). When relay FB operates, a circuit is closed to start the ringing machines, direct ground is removed from the ATB lead to prevent any L2 relay from operating, and an "all finders busy tone" is placed thereon.

If a call is now initiated, the L2 relay will not operate and the all finders busy tone will be heard, indicating an "all-finders-busy" condition.

405 (f) More Than One Call Received At A Time: When several simultaneous calls are made, the finder operates until it finds the lowest level marked for a call, then rotates until it finds the first marked contact. After release, a second finder starts and repeats this process of selection. Calls are selected in the order of their number assignment, 11 being first, followed by the remainder of the first level, other levels, and 00 last.

405 (g) Finder Blocked Key: When the finder blocked key of a finder control circuit is operated, the circuit to relay F4 is opened to cause all calls to be handled by the other group and the circuit to relay P4 is opened to cause the finder control circuit to restore to normal.





limit the testing of the finder control relays and the making of calls as described in Sec. 405 (a). Ground may be placed on the EC lead by shorting springs 3 & 4 of the test line jack to cause the connector to override busy to permit the monitoring of calls.

405 (i) Spark Suppression: Resistance-capacity networks are connected to the rotary and vertical leads to prevent destructive sparking at the contacts of relay A4.

Resistance windings in parallel with the operating windings of release magnet, and relay A4 prevent damage to contacts opening these circuits.

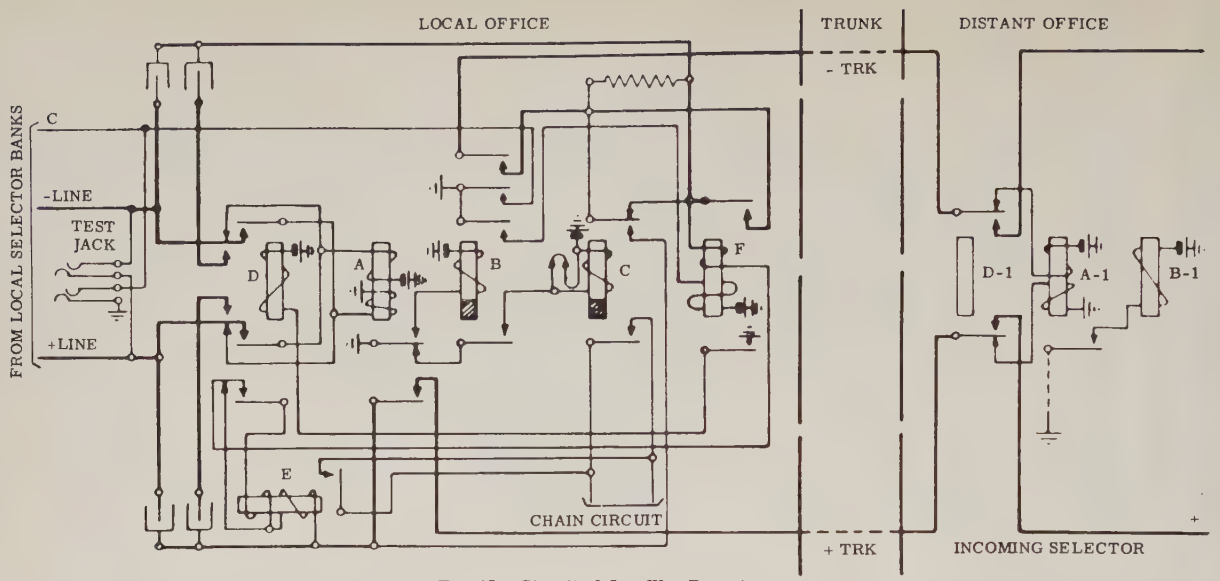



Fig. 15 - Circuit of One-Way Repeater.

406 Impulse Repeater Circuits; The impulse repeater is used in conjunction with Strowger telephone systems serving exchange areas of more than one central office. An impulse repeater is required for each trunk used for outgoing service to another office. The operation of the impulse repeater is entirely electrical; that is, there are no mechanical moving parts involved, such as shaft and wipers. Each impulse repeater, therefore is a fixed component of an inter-office trunk, and consequently, is associated with only one distant central office. It is located in the office in which the calls originate, and is directly connected, by means of the trunk, to an incoming selector (or in case of a 100-line unit, an incoming connector) located in the distant office. This selector is in general similar to the selector regularly employed in the local switch train.

Two types of impulse repeaters are in general use; namely, "one-way" and "two-way" repeaters.

406 (a) Circuit of the One-Way Repeater: The one-way repeater is used to trunk calls from one office to another, in one direction (outgoing) only. Such a repeater is located in the office from which the calls proceed. The two terminations of the inter-office trunk are known as outgoing and incoming, respectively; outgoing in the originating office, and incoming in the terminating office.

The major functions of the one-way impulse repeater are outlined below in the order in which they occur: (1) To ground the control lead in order to hold all the preceding switches in the train operated; (2) to make itself busy against seizure by other calls; (3) to close the trunk loop to the succeeding switch in the distant office, and to repeat impulses to the switches in the distant office train; (4) to reverse the polarity of the current supply to the calling telephone when the polarity of the current supply to the repeater is reversed by the operation of the connector in the distant office; (5) to supply transmission current to the calling telephone; and (6) to allow all the switches involved in the connection t release when the receiver at the calling telephone i restored to the hookswitch.

(A) Seizure: Figure 15 shows in schematic form typical circuit of a one-way impulse repeater. Whe the repeater is seized by the preceding switch (usu ally a local selector), a circuit is completed to lin relay A. This circuit is from ground through th lower winding of relay A, break contact relay D, ov over the +line (including the preceding switches i the train), through the calling telephone, back ove the -line (including the preceding switches), brea contact relay D, and through the upper winding o relay A to -battery.

Relay A operates to close the circuit of relay B Relay B operating, connects ground to the contro lead C to protect and hold operated the switches i the connection preceding the repeater, and also t protect the repeater against seizure by other pre ceding switches. Relay B operating, establishes an other circuit from ground through a make contact o relay B, and the lower winding of relay F to -battery This circuit provides a polarizing field for relay F which is not, however, strong enough to cause th armature of relay F to operate.

(B) Loop To Distant Office: The circuit to the in coming switch at the distant office (assumed to be selector) is also closed by operation of relay B causing relay A-1 of the incoming selector to operate This circuit is from ground, through the lower wind ing of relay A-1, break contact relay D-1, over the +trunk, make contact relay A, the right hand winding of relay E, break contact relay D, upper winding o relay F, break contact relay C, make contact relay B, back over the -trunk, break contact relay D-1, and through the upper winding of relay A-1 to -battery. In addition to operating relay A-1 the closure of the trunk circuit also operates relay E and energizes the upper winding of relay F. At this time, however, the current flowing through the upper winding of relay F

the reverse direction to that flowing through the r polarizing winding; therefore, the magnetic produced by these two windings will oppose each er, preventing relay F from operating. Relay E ses a part of an incomplete chain circuit. When he repeaters in a group are in use, the chain uit is completed through all the chain contacts in es, to operate an "all-trunks-busy" meter.

Impulse Repeating: Each series of impulses de-red by the dial at the calling telephone is repeated o the switch train in the distant office. When the al impulse of each digit permits relay A to re-e to normal, a circuit is established from ground, k contact relay A, make contact relay B, through y C to -battery. Because relay B is of the slow-ase type, it will not be released during the im-ing periods.

ay C also remains operated during each series of ulses, and while in this position maintains a shunt und the upper winding of relay F and the right hand ding of relay E, to provide a low impedance path the repeated impulses. This shunt circuit may be ced from the -trunk, through make contacts on ys B and C and the impulse repeating (make) con-s on relay A to the +trunk. The shunt placed und its right hand winding causes relay E to re-se and remain at normal during each series of ulses. Relay C operating, also closes a make act which is connected in parallel with the make tact of relay E, in order to maintain this part of chain circuit closed when relay E is released.

ay A, responding to impulses delivered by the l at the calling telephone, interrupts the impulse eating circuit to relay A-1 of the distant office in-ning selector, each time relay A restores to nor-l; thus repeating the impulses to the switch train the distant office and causing the switches in this in to complete the dialed connection.

ring the pause between each series of impulses, ay C releases, removing the shunt from the upper ding of relay E; thereby, transferring the trunk p from the low resistance impulsing circuit to a h resistance holding bridge.

e resistance connected across the break contact of ay C is to prevent a momentary opening of the nk loop at relay C when this relay releases after the completion of each series of impulses. This resistance maintains the loop circuit, after the opening of the make contact of relay C removes the low resistance impulsing path (shunt), and before the break contact of this relay closes and re-establishes the high impedance holding bridge across the trunk.

(D) Talking Circuit: When the called person answers, the operation of the back-bridge relay of the connector reverses the polarity of current flow through the holding bridge of the repeater, which includes the upper winding of relay F. The current flow through this winding is now in the same direction as the flow through the polarizing winding, and the combined magnetic flux produced by the two windings will cause relay F to operate. Relay F operating, closes the circuit of relay D.

Relay D operating, reverses the polarity of current flow to the calling telephone for the purpose of operating coin-collectors, message registers or providing supervision in case the call originated at a manual switchboard.

When relay D operates, the left hand winding of relay E is connected in series with the trunk holding bridge, thus increasing its impedance.

The impedance added to the holding bridge, by the operation of relay D, is to improve transmission over the talking circuit. The holding bridge might shunt, or bypass, a considerable portion of the voice currents if it did not offer a high impedance to the flow of such currents.

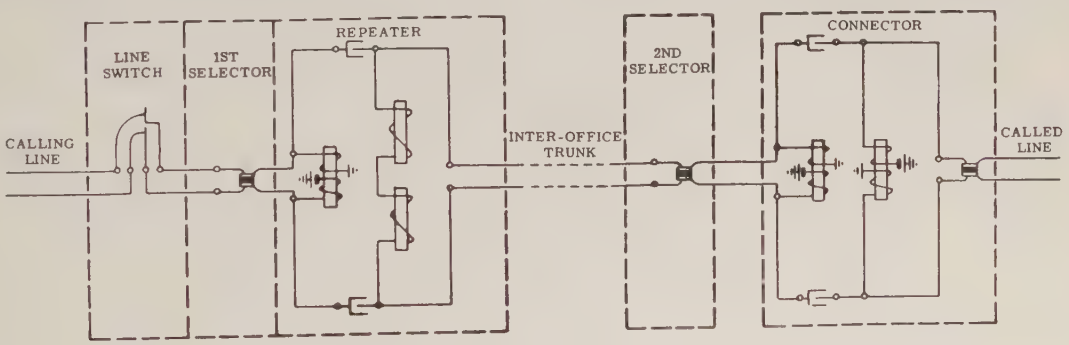



Fig. 16 - Transmission Circuit of an Inter-Office Call.

When required for long trunks, relay D operating, also connects an additional condenser in multiple with the condensers regularly connected in each side of the trunk to improve the transmission of voice currents. These condensers are connected in multiple with the regular condensers only during the period of conversation. The reduced trunk capacity, during the impulsing period, serves to maintain the character of the impulses delivered to relay A.

Figure 16 shows, in simplified form, the transmission circuit of an inter-office call. As will be observed from the figure, transmission current is supplied to the calling telephone, through the two windings of the

line relay of the repeater. Current is supplied through the windings of the line relay of the connector, to the holding bridge of the repeater, in order that the operation of the switch train in the incoming office will be dependent upon the repeater. The back-bridge relay of the connector supplies transmission current to the called telephone.

(E) Releasing: When the receiver at the calling telephone is replaced on the hookswitch, line relay A releases, opening the circuit to relay B, and also the trunk loop. Opening the trunk loop permits the switch train in the distant office to restore to normal. Both windings of relay E and the upper winding of relay F are also de-energized when the trunk loop is opened. Relay E releases, but relay F is held operated by its polarizing winding.

Relay B is slow in releasing and immediately after relay A restores to normal, a circuit is established from ground through break contact relay A, make contact relay B, to relay C. Relay C operating, closes a part of the chain circuit, so that the chain circuit will not be interrupted at this repeater when relay E releases.

Relay B restoring a short time after relay A has released, disconnects ground from the control lead C, permitting all the switches preceding the repeater to restore to normal; and opens the circuit to the winding of relay C which will restore to normal after a short interval of time. Relay B releasing, also opens the - side of the trunk, and interrupts the circuit to the lower winding of relay F, permitting relay F to release. Relay F releasing, opens the circuit to relay D, allowing the latter relay to release.

Relay C, which is slow acting, is the last relay to restore and upon releasing, opens part of the chain circuit. All relays having released, the repeater is at normal and available to other calls.

406 (b) Circuit of the Two-Way Repeater: A two-way repeater makes possible "two-way" operation of inter-office trunks, thereby realizing considerable economy in trunk cable facilities between offices. Where two-way trunking is employed, a repeater of this type is located at each end of the inter-office trunk.

The circuit of a two-way impulse repeater, as shown in Fig. 17, is similar to that of the one-way repeater with the exception that another relay, designated G, is provided. Normally, each two-way inter-office trunk is connected at both ends to an incoming selector or connector, through break contacts of relay G. When the trunk is seized at one end, the incoming selector or connector associated with the repeater at that end is disconnected from the trunk, by the operation of relay G.

On outgoing calls (calls from the originating office to a distant office) when the repeater is seized, line relay A operates, which in turn causes relay B to operate, as described under Sec. 406 (a) (A). Relay B, operating, closes a circuit from ground at a make contact of relay B, through the winding of relay G to battery, causing this relay to operate.

Through the operation of relay G, the incoming selector or connector at the local office is disconnected from the trunk, in order to clear the trunk of attachments at the originating end, and the repeater is connected to the trunk, through make contacts of relay G.

On calls incoming from a distant office to the office in which the repeater under discussion is located, the trunk is normally connected to the incoming selector or connector, through break contacts on relay G. Upon seizure of the incoming selector, ground is connected to the control lead C, by the selector to make the trunk and associated repeater busy to outgoing calls.

Relay G is slow to release, so that on outgoing calls the incoming selector or connector in the distant office will be released before the selector or connector associated with the repeater at the originating office is reconnected to the trunk. This is to prevent "locking-up" the distant office switch train, due to the reversed polarity of battery connected to the trunk at the connector, in case the called person disconnects last.

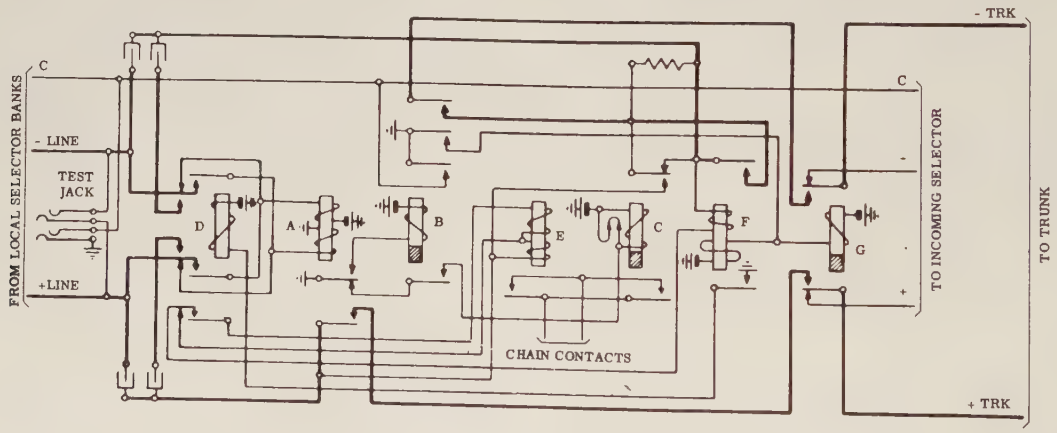



Fig. 17 - Circuit of Two-Way Repeater.

Special Circuit Features: A man working in a n office may be satisfied to merely learn the cuits used in that particular office, but most of us 1 to acquire the ability to "sight read" any circuit, h as a musician in a vaudeville house sight reads piece of music placed before him. Such ability only be acquired by months and years of study. ae reader is familiar with the general principals Part A", the circuit devices of "Part C" and the ceding illustrative circuits of "Part D" he should e no difficulty in reading the following "Special cuit Features", even though in many instances are divorced from the complete circuit.

Connectors of Unusual Capacity

(a) The 10-Line System: A ten line switchboard prising from two to four "selector-connector" s is interesting in that it is small enough to

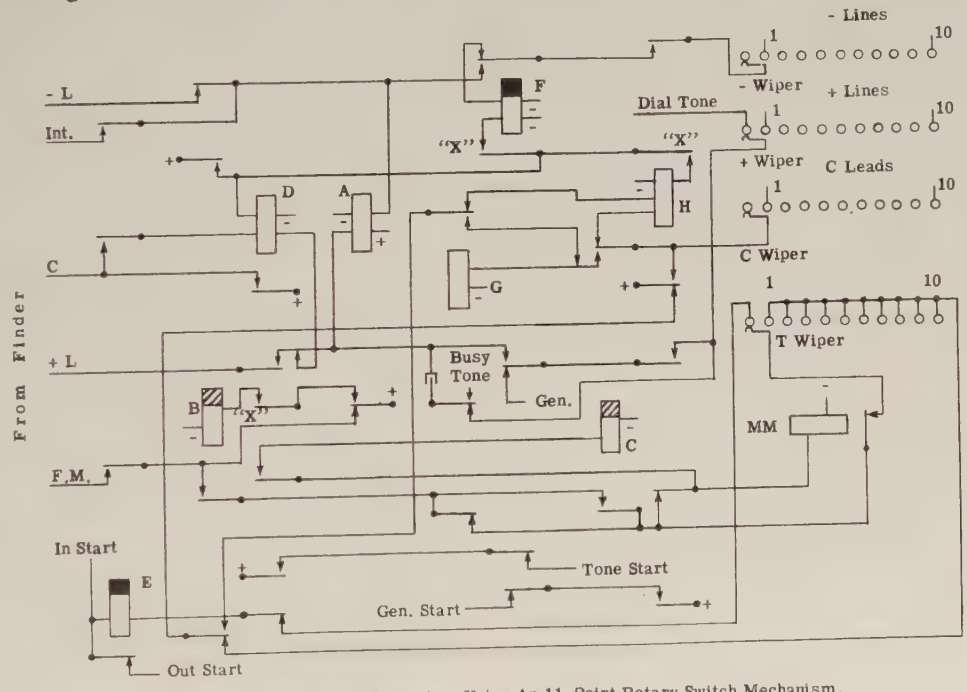



Fig. 1 - The 10-Line Connector, Using An 11-Point Rotary Switch Mechanism.

nprehend yet illustrates many of the special tures found in larger systems. We will first cuss the 10-line connector, then the 10-line finder ., finally, the auxiliary equipment such as tone erators, ringing machines, ringing interrupters, ..

The 10-Line Connector: Refer to Figure 1 which ws a 10-line connector using an 11-point rotary itch mechanism. It might be well for the reader to resh his memory regarding the rotary switch chanism by re-reading Section 208.

t us assume that relay E is operated and that the sociated finder has found the calling line. At this e resistance battery on the "C" lead will pass ough the lower winding of relay D and line relay A ground. Two step relay D closes its "X" contacts ly so that release relay B may energize from ntacts on relay A. Relay B closes the upper winding of relay D and extends "-L" to relay A. Relay D operates completely, returns ground on release trunk "C", extends "+L" to the lower winding of relay A, places ground on the Tone Start lead, and causes the de-energization of relay E. Dial tone is now audible to the calling subscriber by way of the condenser, break springs on relay D and wiper "+" in home position.

Relay A follows the impulses from the calling subscriber's dial and, at each pulse, closes the circuit of motor magnet MM in parallel with relay C. The motor magnet advances the rotary switch wipers from the "home" position into engagement with the bank contacts associated with the called line.

Relay C remains operated during the series of pulses and short circuits a pair of contacts on busy relay G, so that the impulsing circuit will not be opened should relay G operate while wiper "C" is advancing. Relay C will restore after the series of impulses and close a circuit from battery through the combined line and cut-off relay of the called line by way of wiper "C", break springs relay C, lower winding relay H, break springs relay G, make springs relay B, to ground at break springs relay H. Note that dial tone was removed when wiper "+" left its home position.

Relay H locks up by way of its "X" springs and becomes fully operated, connects ringing relay F to the "-" side of the called line and interrupted generator to the "+" side of the called line. Part of the interrupted generator passes through the condenser to the positive side of the line and gives the calling subscriber ring back tone. (See Sec. 205(l). Relay H also opens an incomplete circuit to the motor magnet so that further rotation is impossible, and places ground on the generator start lead.

When the call is answered, ringing relay F operates to remove ground from the "Tone Start" and the "Gen. Start" leads and extends the calling to the called line. Transmission battery is supplied to both the calling and called lines through the windings of relay A. Note the absence of the condensers which usually separate the calling and called lines.

When both the calling and called subscribers have restored their handsets, the loop circuit to both windings of relay A is opened. Relay A then de-energizes to open the circuit of relay B. Relay B falls away to open the circuit of relays D, F and H. Relay D restores to remove ground from release trunk "C", thus freeing the calling line. Relay H restores to remove ground from wiper "C", thus freeing the called line; and closes the circuit of motor

(B) The 10-Line Finder: Refer to Figure 2 whic shows a 10-line finder using an 11-point rotary switc mechanism. Note that the first finder and the firs connector are associated to comprise the first o several links. The connector may be assumed to b that discussed in Sub-Section (A) above. Only th connector portion of the "second" and "last" link is indicated.

Line eight of this ten line system is shown wired t the combined line and cut-off relay LR, which is th same line relay as that discussed in Section 401(d) This line has an appearance in the banks of all finders and the associated "normals" are multipled throug all of the connector banks. At the lower left of th figure is a "common line relay L", which is multi- pled to a certain spring on all relays LR of the system

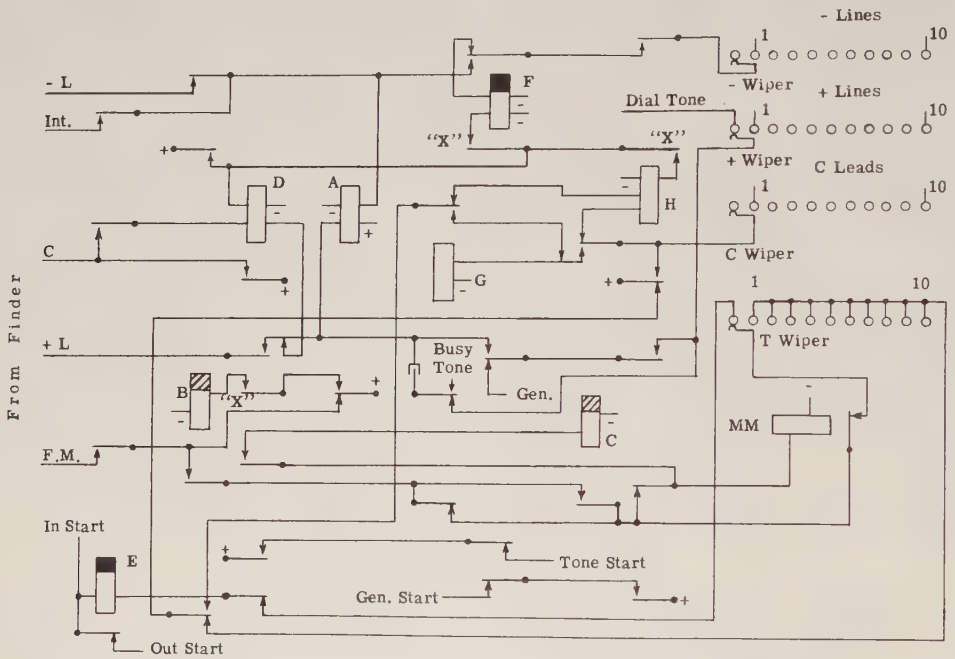



Fig. 1 - The 10-Line Connector, Using An 11-Point Rotary Switch Mechanism. (Repeated)

magnet MM by way of break springs relay B, multipled bank contacts and bridging wiper "T", break springs on MM and break springs on relay H. The motor magnet interrupts its own circuit and drives all wipers to their home position.

If the called line is busy, relay G will be energized from ground encountered by wiper "C". Relay G operates to open an incomplete circuit to relay H (to prevent the operation of relay H in the event the called line becomes free), and connects busy tone to the calling line through the condenser. Relay G also opens an incomplete circuit to relay C and the motor magnet, so that further rotation is impossible. Relay C de-energizes and locks up relay G, thus making it independent of the condition of the called line.

When the calling subscriber restores his handset, the circuit of relay A is opened and the switch returns to home position as described above.

It will be remembered that the connector has a "home" position, but note that the finders "stand where last used."

When a call is originated on line #8 the upper winding of the individual line relay LR is energized in series with the common line relay L. Two-step relay LR operates only to close its "X" contacts, thereby "marking" the eighth contact in the bank accessible to wiper C of the finder.

Common line relay L operates and places ground on the "in lead" to the first connector of the group. Assuming that the first link is idle, connector relay E will energize in series with its associated motor magnet, (MM will not operate at this time because of the high resistance of relay E).

Relay E operates to close the circuit of finder switch motor magnet MM by way of break springs on relay A and lead FM. Motor magnet MM energizes (remember

ipers do not advance at this time), and closes the it of relay A by way of lead Int. and make springs lay E. Relay A operates to open the circuit of which restores to advance its wipers one step pen the circuit of relay A. These alternate tions of MM and relay A continue until wiper C e finder encounters a contact in its bank marked sistance battery.

Relay E falls away to extend the chain to relay E of the next idle link, so that another call may be initiated while this call is in progress.

Upon release of the connector, relay D removes ground from the "C" lead, whereupon line relay RL restores. The finder switch remains where last used.

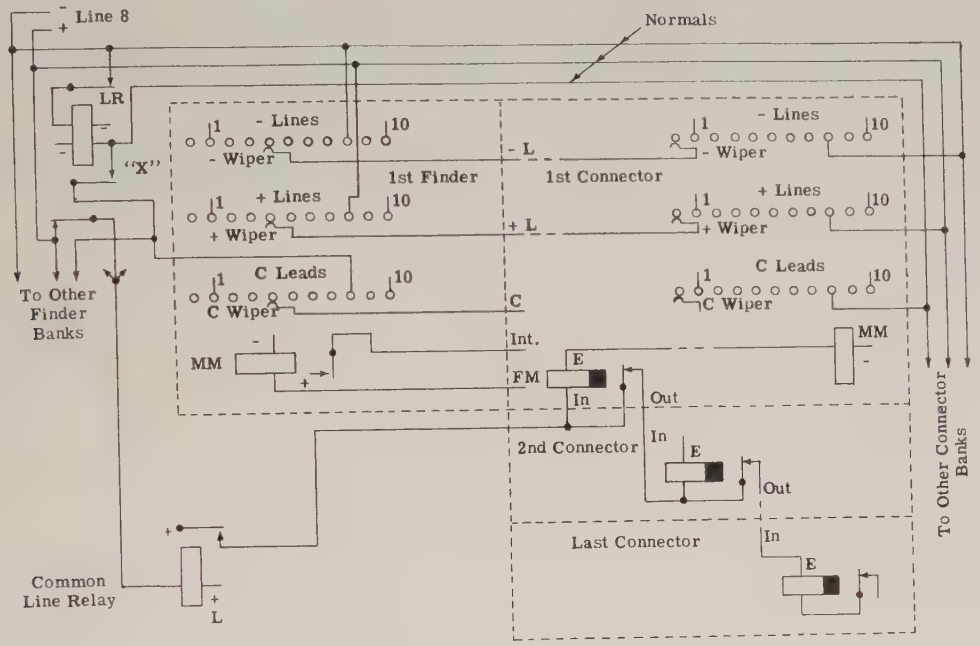



Fig. 2 - The 10-Line Finder Using An 11-Point Rotary Mechanism.

n wiper C of the finder switch engages the eighth act, a circuit is closed from battery through the r winding of relay LR, "X" contacts thereon, r C, make springs relay E, lower winding relay D break springs thereon to ground through the lower ling of relay A. Two-step relay D operates its ' contacts only to close the circuit of relay B. ay A remains operated by virtue of its lower ling, thus stopping the rotation of the finder.

If all the links were in use, a subscriber attempting to make another call would not receive dial tone.

(C) Auxiliary Equipment: At the left of Figure 3 will be found relays U, T and transformer W, which form a "ringing converter," i.e. direct current is transformed into ringing current. Next are relays R, N and P which comprise a "ringing interrupter." At the extreme right is relay S which functions as a "tone

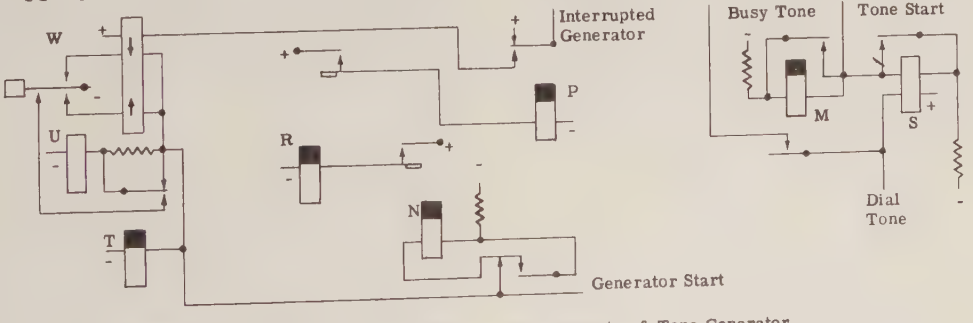



Fig. 3 - Ringing Converter, Ringing Interrupter, Busy Interrupter & Tone Generator

ay B closes the upper winding of relay D, which omes fully operated to place direct ground on uductor C, and open the circuit of relay E. Direct und on conductor C causes the complete operation ine relay LR, thereby removing its upper winding m the negative side of line #8 and common relay L m the positive side of line #8. The direct ground sses over the C normal to make this line busy in banks of the connector switches.

generator. Further to the left is relay M which operates as a "busy tone interrupter."

Relays R and N are "weighted spring relays" as discussed in Section 318(a). Relay U is a "vibrating reed relay" as discussed in Section 319(a), although the circuit function here differs from that previously described.

In small systems, such as we are discussing, relay vibrators and interrupters are entirely satisfactory. In medium sized installations the apparatus becomes more sturdy, and in very large installations it is customary to find rotating machinery.

When ground is placed on the Tone Start lead, the upper winding of relay S is energized through a limiting resistance. Relay S operates to short circuit its upper winding, then releases and starts the cycle over again. The action is that of a high pitched buzzer and the current pulsates between a maximum and a minimum. An alternating current is induced in the lower winding which produces dial tone for distribution to the several connectors.

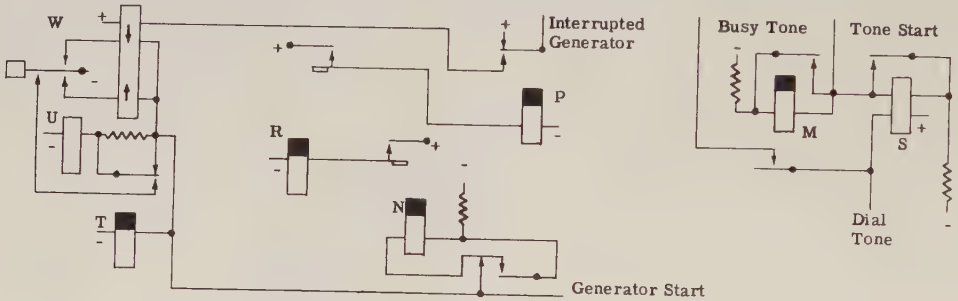



Fig. 1- Ringing Converter, Ringing Interrupter, Busy Interrupter & Tone Generator (Repeated).

Relay M functions in a similar manner, but is somewhat slow in operation because of the slug on the armature end of the core. Relay M extends interrupted dial tone to the Busy Tone lead.

(C1) Ringing Converter (Pole Changer): Ground on the generator start lead places full potential on "vibrating reed relay" U, and on slow to operate relay T. Relay U energizes with a large amplitude (this is sometimes called "thump start") and closes both lower make contacts. Relay T eventually energizes to insert a limiting resistance in the circuit of relay U, and completes a circuit whereby relay U short circuits itself.

Relay U now restores to remove its short circuit, at which time the momentum of the weighted reed causes the closure of its upper make contact. Relay U again energizes in series with the limiting resistance and continues to vibrate with "normal amplitude" so long as ground remains on the generator start lead.

It will be noted that the two lower windings of transformer W are in opposition, therefore the action of relay U will produce an alternating field in the core of transformer W. It follows then that an alternating potential of approximately 25 cycles per second will be induced in the upper winding of the transformer W.

(C2) Ringing Interrupter: Ground on the generator start lead also closes the circuit of "weighted spring" relay N and a limiting resistance. Relay N operates to intermittently close the circuit of slow to operate relay R. Relay R will eventually energize to set in vibration its own weighted spring, thus closing the circuit of relay P. In due time relay P will operate to short circuit relay N.

Relay N, slow to restore because of the short circuit will fall away and open the circuit of relay R. Rela R, slow to restore because of its slug, will fall awa to open the circuit of relay P. Relay P, also slow t restore because of its slug, will fall away to remov the short circuit on relay N.

Relay N re-operates and the cycle continues so lon as ground is maintained on the generator start lead At each energization of relay P the interrupted generator lead is switched from ground to the ringing transformer W.

408(b) The 22-Line Connector: Refer to Figure 2 which shows a 22-line connector using a 25-point

rotary switch mechanism. It might be well for the reader to refresh his memory regarding the rotary switch mechanism by re-reading Section 208. In connection with this particular switch the reader must distinguish between "line numbers" and bank contact numbers.

Refer to wiper T and the bank with which it is associated. The wiper is obviously standing on the "home" or 25th contact, the other contacts are numbered in accordance with the number of steps necessary to reach any given contact.

The line numbers appear in three groups. A line in the first group (1 to 9) may be reached by a single pull of the dial. Lines in the second group (01 to 09) can be reached by two pulls of the dial. Lines in the third group (001 to 004) can be reached by three pulls of the dial.

When a call is extended to this switch line relay A and release relay B operate in the usual manner. Relay A follows the impulses from the calling subscriber's dial and, at each restoration, closes the circuit of relay C and the motor magnet. Relay C short circuits its upper winding and remains operated during an entire series of impulses. (This is another interesting "circuit kink" - a relay quick to operate but slow to release because it short circuits its own low resistance winding).

Since contact numbers 10 and 20 in the bank served by the C wiper are not connected to either ground or battery, neither "busy" relay G nor "wiper closing" relay H, can operate to open the pulsing circuit when the C wiper is resting on those contacts. See circuit described in Section 408(a)(A).

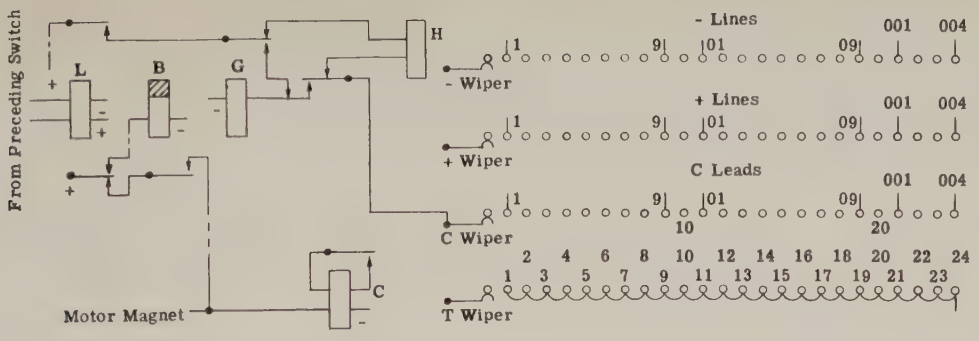



Fig. 2 - The 22-Line Connector, Using a 25-Point Rotary Switch Mechanism

c) The 200-Line Connector: In Section 132 it was that the mechanics of this switch are the same aat of the ordinary connector, the difference being the wipers have access to two line banks and one contact private bank. If the switch is moved up in "XX" steps, one set of wipers will be standing ne bank contacts of the "XX" line in the first rred group, while the other set of wipers will be ding on the "XX" line in the second hundred group. problem then is to select one or the other set of rs.

Wiper Selection Made at Banks of Preceding ch: Refer now to Figure 3 and note that if the ch is seized from the "selector banks serving group" the line relay A and the release relay B function in the usual manner. Relay B will close ircuit of relay G, but without effect at this time. The connector will complete its remaining functions and the calling party will be connected to the "XX" line in the first hundred group.

If, however, this switch is seized from the "selector banks serving 200 group" the circuit to the lower winding of relay A will be completed by way of the lower winding of relay M. Relay M will energize and, (1) lock itself up by way of the "X" contacts, (2) shunt out its lower winding, and (3) transfer the "-", "+" and C circuits to the lower set of wipers.

This particular switch is "trunk hunting" only in the 200-group. Therefore there is but one EC wiper, and it is effective only when relay M is operated.

Note that this same circuit device was used in Fig. 13, Section 404(a), to determine the side of the line on which the called line is to be rung.

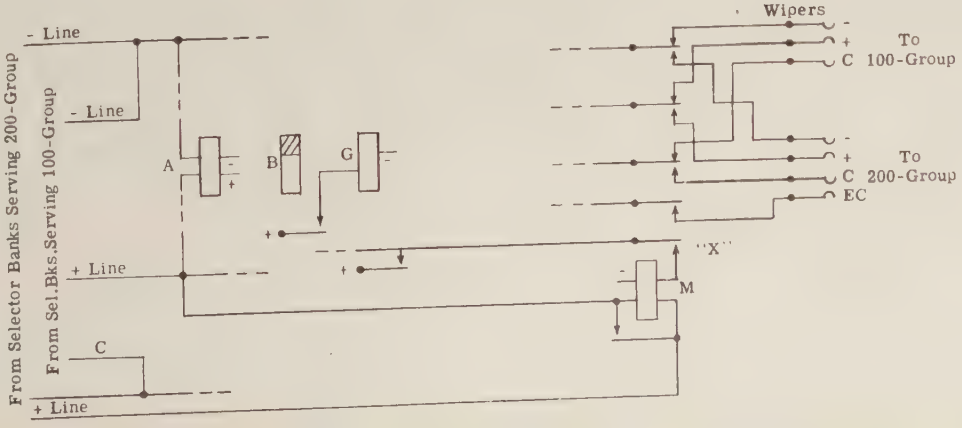



Fig. 3 - The 200-Line Connector. Wiper Selection Made at Banks of Preceding Switch

(B) Wiper Selection Made Within the Connector: When the wiper selection is to be made within the connector, the wiper selecting digit must operate some circuit device to cause the change of wipers.

(B1) By Use of Counting Relays: Refer now to Figure 1 and note that the counting relays F and K are "two step" relays, and that relay K functions to transfer the "-", "+", and C circuits to the lower set of wipers. The wiper selection is determined by the first digit dialed. If the first digit dialed is a "1", relay F only operates and the upper wipers function. If the first digit dialed is a "2", both relays F and K operate and the lower wipers become associated with the circuit.

Shortly after the end of the first digit (be it either o or two pulse), relay C will de-energize and close t circuit of relay L. Relay L now energizes to dire the pulsing circuit to the vertical magnets.

Compare this counting chain with that shown Section 311.

(B2) By Use of Minor Switch: The switch selected illustrate this feature is quite complicated in that represents a 200-line connector capable of providi fully selective ringing on a 10-party line. Refres your memory regarding the minor switch by re reading Section 147.

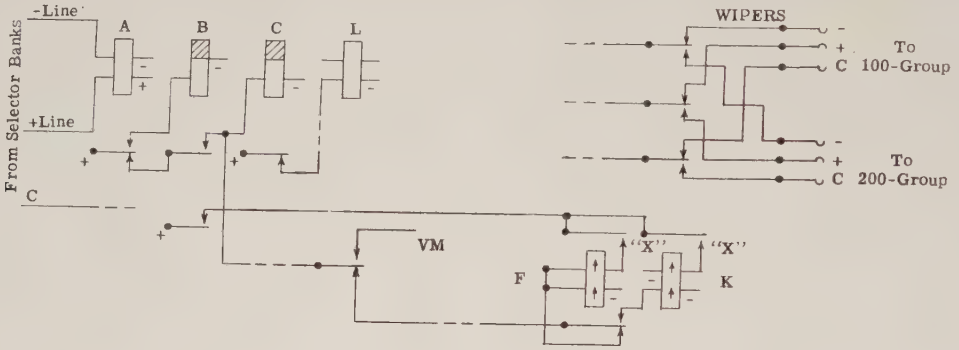



Fig. 1 - 200-Line Connector. Selection made within the connector by counting relays

When this switch is seized, line relay A and release relay B function in the usual manner. At the first pulse of the first digit a circuit is closed to relay C and the lower winding of relay F, which operates its "X" contacts only. (Note that at this time the upper winding is shunted, "+" battery on both sides).

At the end of the first pulse of the first digit, slow to release relay C will remain operated, and relay F will become fully operated to transfer the counting chain to relay K. At the second pulse of the first digit, relay K will energize to operate its "X" contacts only. At the end of the second pulse of the first digit, relay C remains operated for a fraction of a second during which time relay K becomes fully operated.

The first two digits dialed on this switch cause the customary vertical and rotary movements, the third digit advances the wipers of a minor switch to, (1) select the hundred group (100-group or 200-group), (2) select the "generator current" (this may be either five different harmonic frequencies or five different codes. In either case "battery connected" generator is used), and (3) select the side of the line for ringing.

If the last digit dialed is from "1" to "5" the 100-group will be served and a certain "generator current" will be selected. If the last digit dialed is from "6" to "0" the 200-group will be served and a certain "generator current" will be selected.

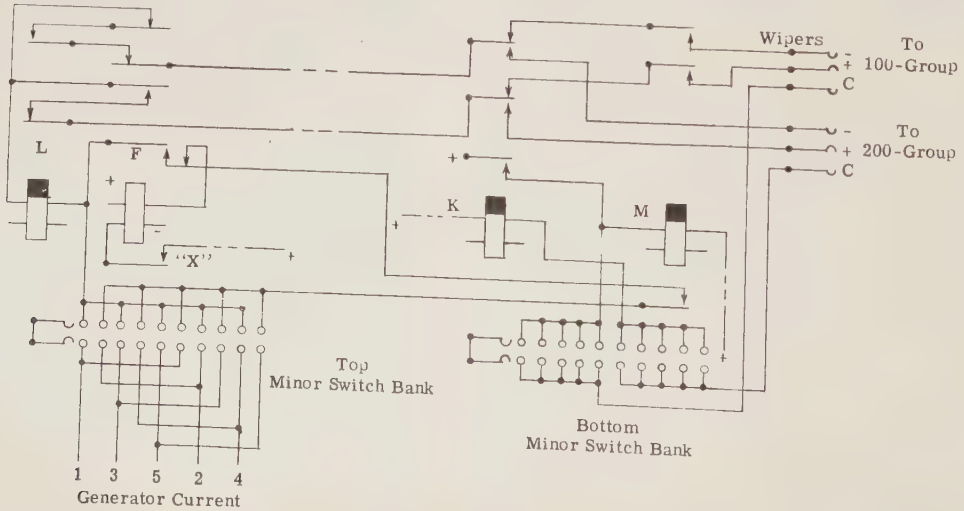



Fig. 2 - The 200-Line Connector. Wiper Selection Made by Use of a Minor Switch

e last digit dialed is even (2, 4, 6, 8 or 0) the
ted generator current is placed on the "+" side
e dialed line, while if the last digit dialed is odd
, 5, 7 or 9) the selected generator current is
ed on the "-" side of the dialed line.

r to Figure 2 and assume that the third digit
ed on this switch has advanced the minor switch
rs three steps. When the C relay (not shown)
nergizes after completion of the third digit,
M will energize from battery over the C wiper
e 100-group, and extend the switch circuit to the
and "+" wipers of the 100-group. As the digit
d was "odd", battery connected #3 generator
ent passes directly to ringing relay L, and thence
ay of make springs on relay M to the negative
of the called line.

e digit dialed had been a "4", an "even" digit,
y M would have operated as before, but this time
tive battery (from the #4 generator current)
d be passed to relay F. Relay F operates to lock
f up, open its operating circuit, and pass #4
rator current through relay L and springs on
ated relay F and M to the positive side of the
d line.

me now that the third digit dialed on this switch
advanced the minor switch wipers seven steps.
n the C relay (not shown) de-energizes after
pletion of the third digit, relay K will energize
n battery over the C wiper in the 200-group,
nd the switch circuit to the "-" and "+" wipers
e 200-group, and close the circuit of relay M. As
digit dialed was "odd", battery connected #2
erator current passes directly to the ringing relay
nd thence by way of make springs on relay K to
positive side of the called line.

e digit dialed had been an "8", an even digit,
y K would have operated as before, but this time
ative battery (from the #3 generator current) would
assed to relay F by way of make springs on relay
Relay F operates to lock itself up, open its oper-
g circuit, and pass #3 generator current through
y L and springs on operated relays F and K to the
tive side of the called line.

The 190-Line Connector: In Section 132(e) mention made of an old time connector which would pond to three operations of the dial. The first ld cause a vertical movement of from one to ten ls, the second and third might then cause a total ry movement of twenty steps.

The two-digit rotary stepping was very similar to that described above in Section 408(a)(B). This particular Strowger connector was made in the days of the "side switch" (see Sections 307 and 335(c)), and the cam operative on the tenth rotary step merely insured that the side switch could not pass from "second" to "third" position.

In modern connectors the "prevention of further rotation" (see Section 205(g), is usually accomplished by providing a relay which will fall away and cannot again become energized. For illustration see relay E discussed in Section 404(c).

If anyone would now want one of these 190-line connectors (which is rather doubtful because the second set of wipers "standing out in the air" were always getting jammed) it would merely be necessary to mount a pair of rotary cam springs "operated only on the tenth rotary step" which would function to shunt the existing RON springs of Section 404(c).

Then, if the first rotary digit dialed were less than ten, further rotation would be impossible. But if the first rotary digit dialed was an "0", the switch could then respond to an additional rotary digit.

409 Trunk Hunting Connectors: Section 215(b) describes three types of trunk hunting connectors. It is beyond the scope of this text to enter into a discussion of the relative merits of the different circuits. We merely present typical circuits in order that the reader may become familiar with the art and gain a knowledge of many circuit devices, a term which Doctor Smith prefers to the writer's proletarian "circuit kinks".

In the sub-sections to follow we will consider a single level in the private bank served by a trunk hunting connector. The upper contacts are the "C normals" and are wired to the associated line equipment. The EC contacts are unwired, except for the strapping shown in the figure.

409(a) Without Night Service Feature: See Section 215(b)(F) for a discussion of this feature. Refer now to Figure 1 and note that the bank level shown is divided into two group of lines or trunks. The term "lines" would be used when the circuits terminate in individual telephones, the term "trunks" should be used when the circuits terminate in a P.B.X. Note further that the grouping is established by strapping the upper and lower bank contacts of each line in the group, except the last.

Disregarding the seizure and vertical operation of this connector; it will be seen that, at the first pulse of the rotary digit, relay E and the rotary magnet RM energize in series by way of the RON (rotary off-normal) springs. Relay E operates to shunt RON, which open at the first rotary step, and closes the circuit of relay J. Relay J energizes to extend relay H to the C wiper.

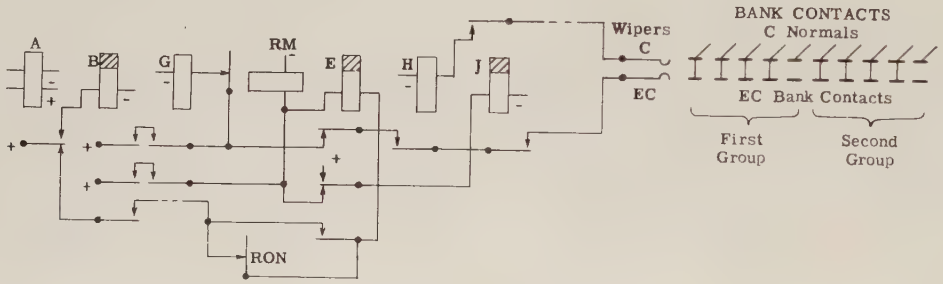



Fig. 1 - Trunk Hunting Connector, Without Night Service Feature.

Shortly after the end of the rotary digit, slow to release relay E will fall away and cannot again become energized. Relay J will not immediately release and, if the first line of the called group is busy, the C wiper encounters ground on the C normal contact to close the circuit of relay H.

Relay H energizes to extend ground, via the strap and wiper EC, to relay G. Relay G operates to lock itself up independent of ground on the EC wiper, and closes a circuit to RM and also to relay J.

The rotary magnet steps the bridging wipers to the next pair of bank contacts and opens the circuit of relay G. Relay G restores and opens the circuit to RM and relay J. The rotary magnet now de-energizes (but not relay J), and again extends relay G to the EC wiper.

Each line in the group is tested in the manner described above until, (1) a free line is found, or (2) the last line in the group is reached. If a free line is found, relay H will fall away and the line in question will be seized by virtue of circuits not shown in the figure.

When an "all lines busy" condition exists, relay G cannot re-operate as the C normal and EC contacts are not strapped together on that line. The calling subscriber will now receive busy tone by virtue of circuits not shown in the figure.

409(b) Without Night Service Feature, Second Illustration: Refer now to Figure 2 and note that the bank level shown is divided into two groups of trunks, and that the grouping is established by strapping the upper and lower bank contacts of the last trunk in the group.

At the first pulse of the rotary digit, relay E and the rotary magnet RM energize in series by way of break springs on relay H. Relay E operates to shunt the break springs of relay H, and closes the circuit of relay J. Relay J energizes to extend relay H to the EC wiper.

Shortly after the end of the rotary digit, slow to release relay E will fall away and open the circuit of relay J. Relay J will not immediately release and, if

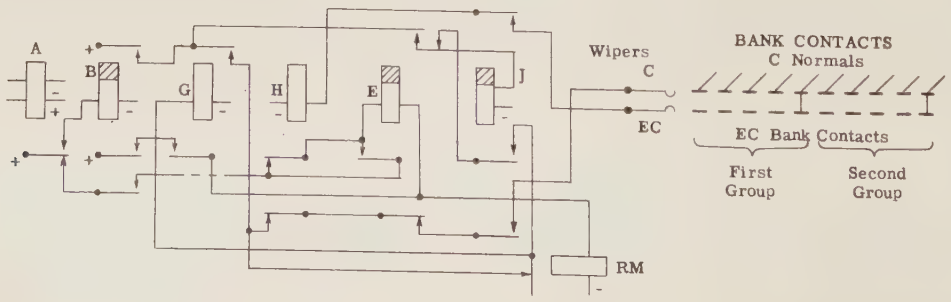



Fig. 2 - Trunk Hunting Connector. Second Illustration.

rst trunk of the called group is busy, the C wiper nters ground on the C normal contact to close rcuit of relay G by way of break springs on the y magnet.

G energizes to lock itself up independent of d on the C wiper, and extends ground direct to nd, by way of break springs RM, make springs J and break springs relay E, to relay J.

otary magnet steps the bridging wipers to the air of bank contacts and opens the circuit of G. Relay G restores and opens the circuit of d relay J. The rotary magnet now de-energizes ot relay J), and again extends relay G to the er.

trunk in the group is tested in the manner ibed above until, (1) a free trunk is found, or e last trunk in the group is reached. If a free is found, relay G cannot again operate because istance battery (B.C.O. of the called trunk) then nt on the C normal contact, and the trunk will be d by virtue of circuits not shown in the figure.

service'' can be rendered by the circuits discussed in Sections 409(a) and 409(b).

Note that the grouping in Figure 3 is established by grounding the lower bank contact of the first line in each group (this is the ''pilot'' number), and by connecting a resistance between the upper and lower bank contacts of the last line in each group.

(A) Calling An Individual Line: Disregarding the seizure and vertical operation of this connector; it will be seen that, at the first pulse of the rotary digit, relay E and the rotary magnet RM are energized in parallel. Relay E operates to extend the C wiper to relay H, but without effect at this time, and the rotary magnet advances the wipers one step.

Shortly after the end of the rotary digit, relay E will fall away and direct the C wiper to the upper winding of relay J, and thence to release trunk ground at the springs of relay B. Relay J will energize in series with the B.C.O. of the called line equipment, assuming that the called line is idle.

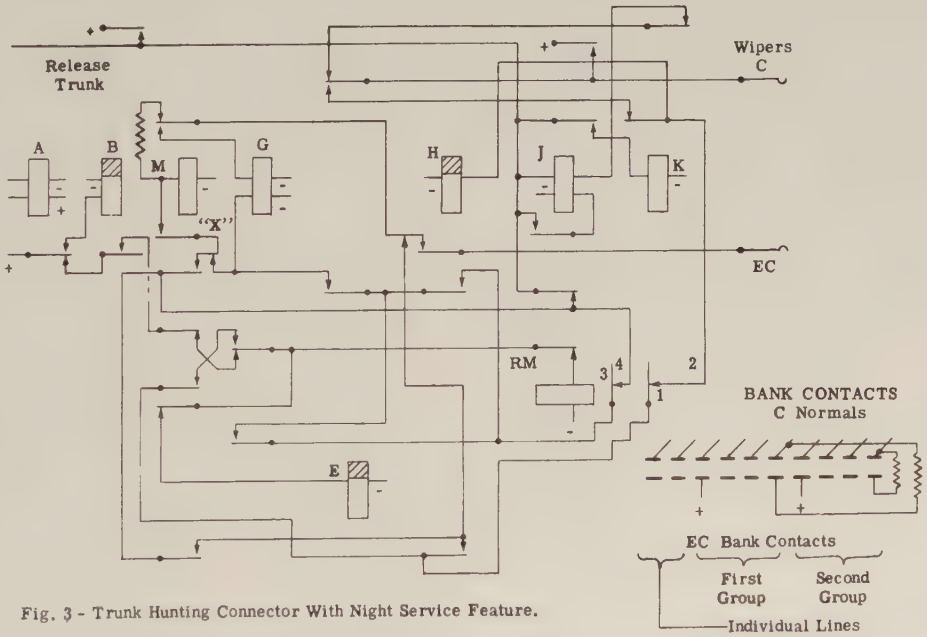



Fig. 3 - Trunk Hunting Connector With Night Service Feature.

an ''all trunks busy'' condition exists, relay H will e from ground via the strap between the C and EC ntacts to prevent the further operation of relay G. alling subscriber will now receive busy tone by of circuits not shown in the figure. At this point dent of circuit design might well go back and re- ubsection 210(e).

With Night Service Feature: See Section 215(b)(E) iscussion of this feature. Refer now to Figure 3 te that the bank level shown is divided into three The first two pairs of contacts are not strapped e labelled ''individual lines''. The next four pairs tacts form the first group, and the last four the l group.

we think of it, the reader will gain good ''skull ce'' by figuring out whether or not ''individual line

Relay J energizes to lock its lower winding to release trunk ground, places direct ground on the C wiper, opens the circuit of the rotary magnet, and closes the circuit of relay K. Wiper closing relay K extends the ringing and talking conductors to the called line by virtue of circuits not shown in the figure.

In the event the called line is busy, relay H will energize from ground on the bank contact engaged by wiper C. Relay H energizes and, when slow to release relay E falls away, closes the lower winding of relay G. Relay G operates to lock itself up independent of break springs on relay H, and places busy tone on the calling line (not shown).

(B) Calling a Pilot Number: Relay E will operate as previously explained to extend the C wiper to relay H.

If the pilot number chances to be idle, relay H will not operate and, upon the de-energization of relay E, relay J functions to complete the connection as above described.

But if the pilot number is busy, relay H operates as before and, this time, extends ground at the bank contact engaged by wiper EC through a limiting resistance to "two-step" relay M. Whereupon relay M operates to close its "X" contacts only.

Shortly after the end of the rotary digit, relay E will fall away and place direct ground on relay M and the lower winding of relay G by way of make springs relay H, break springs RM, and break springs relay J to release trunk ground.

Relay M becomes fully operated, locks its self up to release trunk ground by way of break springs on relay J, transfers the EC wiper from its own starting circuit to the upper winding of relay G, and provides a holding circuit for relay H (independent of the C wiper) by way of break springs RM, make springs relay H, make springs relay M, and break springs relay J to release trunk ground.

Relay G operates, closes the circuit of the rotary magnet by way of break springs relay J, make springs relay G, make springs relay M, make springs relay H, make springs relay M, and break springs relay J to release trunk ground.

The rotary magnet operates to open the lower winding of relay G, advances the EC wiper to the next bank contact (which is free of ground), and opens the locking circuit of relay H. Slow to release relay H does not restore at this time. Relay G restores (its upper winding is open to the EC wiper, and its lower winding is open at break springs of RM), and opens the circuit of the rotary magnet.

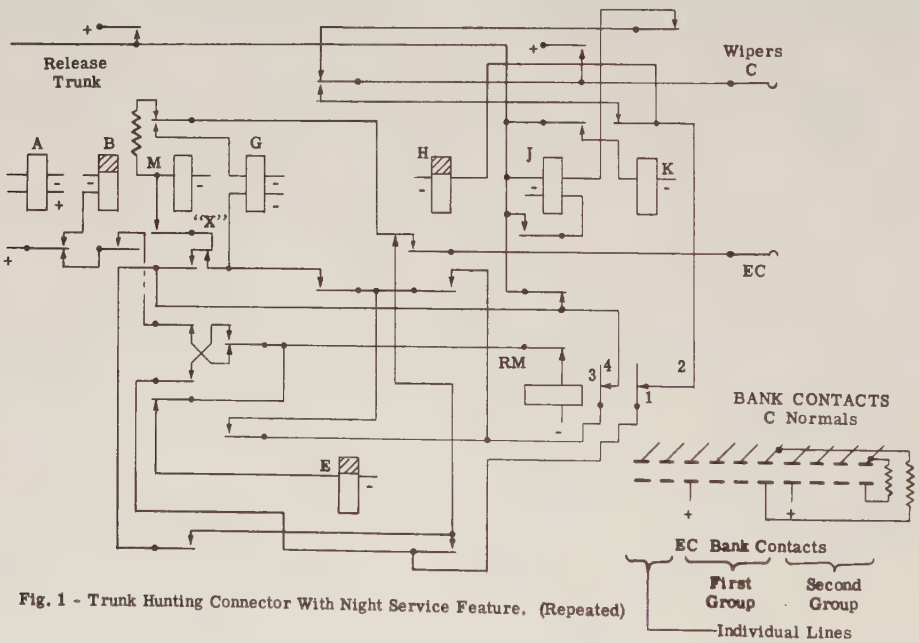



Fig. 1 - Trunk Hunting Connector With Night Service Feature. (Repeated)

The rotary magnet now restores to again close t lower winding of relay G and the locking circuit relay H.

The rotary magnet will operate and restore alternate with relay G until, (1) a free trunk is found, or (2) t last trunk in the group is reached. If a free line found, resistance battery (B.C.O. of the called line) present on the C lead and the circuit to relay J completed as explained above. Relay J will opera quick enough, at the first idle trunk, to stop the rotatio

When an "all trunks busy" condition exists, the upp winding of relay G will be energized from resistan ground via the connection between the C and EC ba contacts. Therefore, relay G will remain operate the rotation will cease, and busy tone will be audib to the calling subscriber.

410 Level Hunting Connector, With Night Servi Feature: The various functions of the Level Huntin connector were well explained in Section 215(c). Th circuit operates much the same as that explained Section 409(c) as to, (1) reaching the pilot numbe (2) automatic rotation, and (3) an all trunks bu condition. We need therefore concern ourselves on with the circuit devices which permit the switch search over higher levels of bank contacts.

Refer to Figure 2 and note that the first two levels a Strowger bank are indicated. The group sho consists of trunks 11, 12, 13, 14, 15, 16, 17, 18, 1 20, 21, 22, 23, 24 and 25. A busy condition is indicat on all the trunks of the first level. If the pilot numb 11 is dialed, the level hunting connector must sear over the first level and, finding all trunks there busy, must reverse its movement until the wipers a clear of the bank and then raise the wipers one ste after which it will search over the second leve

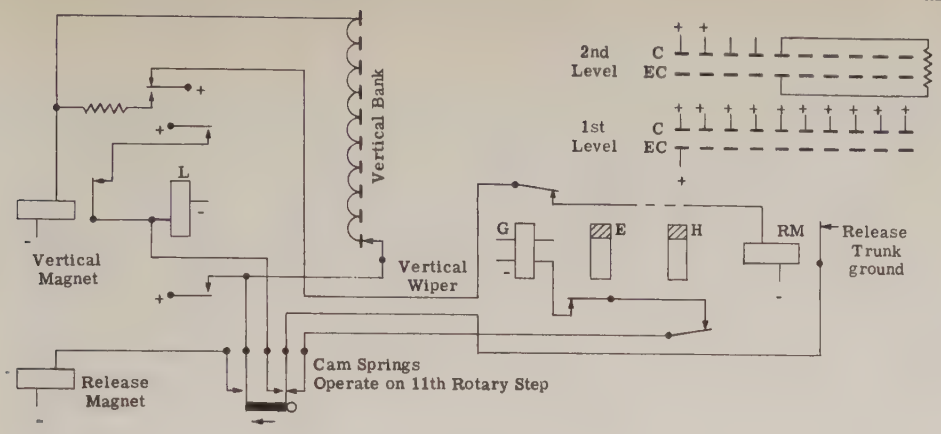



Fig. 2 - Level Hunting Connector.

ted relay G, non-operated relay E and operated H are symbolical of corresponding relays discussed ion 409(c).

he "vertical bank" and "vertical wiper", and to Figure 2, page 35, for an understanding of relationship to the Strowger banks. Note also am springs" that operate on the eleventh rotary

ll assume that the switch has been raised one nd is searching over the busy trunks in the first From Section 409(c)(B) we know that relay H ns operated, and that the rotary magnet will te and restore alternately with relay G.

eleventh rotary step the rotary magnet advances bers clear of the bank, operates the cam springs direction indicated and opens the circuit of G. Relay G restores and opens the circuit of ary magnet, whereupon the rotary magnet would lly restore to close the circuits of relay G, but -

am springs have operated to transfer release round from relay G to relay L. Relay L operates ove ground from the circuit of the rotary magnet, resistance ground on the vertical magnet, locks p independent of the cam springs, places ground on tical wiper, and closes the circuit of the release

osely at Figure 2, page 35, and realize that at this e vertical wiper has rotated free of the vertical Also that the vertical magnet, energized through iting resistance, is trying to raise the shaft one step, but that it cannot do so because of the onary dog."

elease magnet functions to free the shaft by aging the "double dog" and locking it under the se link", see Section 161. The shaft is now free ate to the left under the influence of the "shaft ", even though it is jammed against the stationary the partial energization of the vertical magnet.

m springs restore to their normal position when aft starts its backward rotation, thus opening the t of the release magnet, and again energizing G. When the backward rotation is complete, the clear of the Strowger bank and the shaft clear of the stationary dog, the shaft remains "one step up" because of the partially energized vertical magnet.

At this time the vertical wiper re-engages the first vertical bank contact and places direct ground on the vertical magnet. The vertical magnet energizes fully to raise the shaft and wipers one step and, in doing so, raises the release link to free the double dog. Break springs on the vertical magnet open the circuit of relay L.

Relay L restores to open both circuits to the vertical magnet. The vertical magnet de-energizes, but the shaft and wipers remain opposite the second level of bank contact because the double dog has fallen in.

The shaft and wipers are now ready to rotate in on the second level of the Strowger bank in search of an idle trunk. Our next problem is how to get the first rotary step.

When the circuit was transferred from relay G to relay L the rotation ceased, and relay H remained locked up through break springs of the rotary magnet. When the cam springs restored to normal, a circuit was again established to relay G, but the circuit to the rotary magnet is held open until relay L restores after the full operation of the vertical magnet.

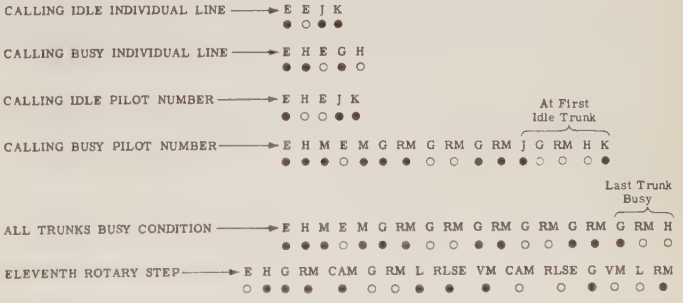



FIG. 3 - RELAY CHART LEVEL HUNTING CONNECTOR.

410(a) Relay Chart: When an intricate circuit is to be analyzed, the student may find it advisable to make up a "relay chart" similar to that shown in Figure 3. The relay operations are shown in sequence. A black dot means a given relay is energized, while an open circle indicates that the relay in question is de-energized.

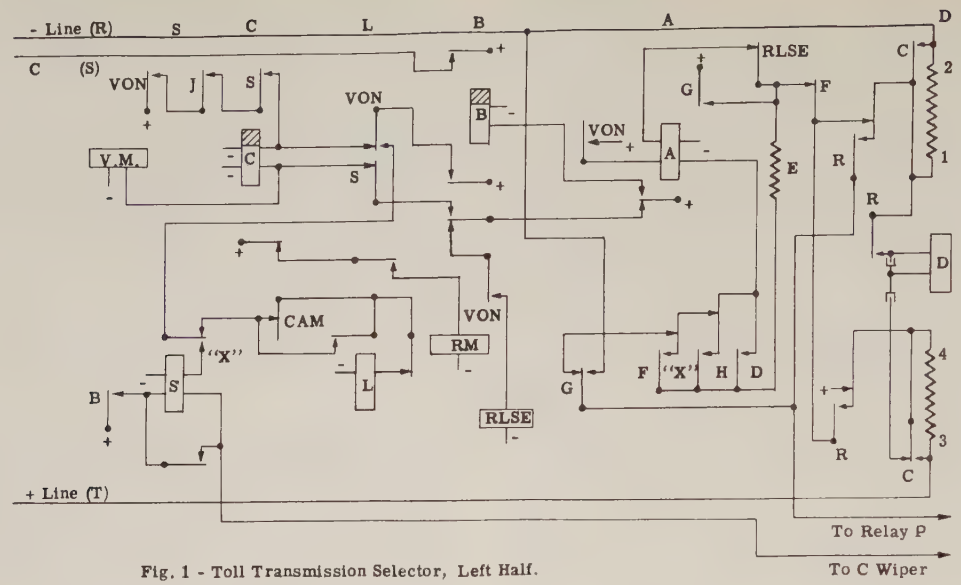



Fig. 1 - Toll Transmission Selector, Left Half.

411 The Toll Switch Train: The toll switch train was previously discussed in Sections 116 and 216. The various switches of a local switch train are rather easy to describe because each is very largely self contained. But in the toll switch train, each switch is so dependent on others that there is no good place to get started.

411(a) Toll Transmission Selector: In Strowger practice the connector of a local switch train feeds transmission battery to both the calling and called parties, and a pair of condensers separates the two circuits. In Strowger toll practice the called party receives transmission battery from the toll transmission selector, usually the first switch in the toll train. Also, in toll practice a repeating coil is used to separate the calling and called circuits.

Refer now to Figures 1 and 2 which is a rather weird circuit combination using both "attached" and "detached" contacts. It is probably only slightly more difficult to read than was the original circuit, which closely filled a blue print measuring 13" x 22". Remember that detached lever springs move to the right, (1) to open a "break" contact, or (2) to close a "make" contact.

At the right of Figure 1 is one half of a repeating coil, this serves as a battery feed to the calling party. At the left of Figure 2 is the other half of the repeating coil, which serves to feed battery to the called party. Voice frequency currents are transmitted through the repeating coil by way of windings 5-6-7-8 and windings 1-2-3-4.

If this circuit is to be seized from a toll board the conductors at the left of Figure 1 would be called "R" (ring), "S" (sleeve) and "T" (tip), but if seized from a preceding switch the words "-" Line, "C" and "+" Line would be used.

(A) Seizure: This switch is marked idle by the absence of ground on the C lead. Closing the circuit from the toll board extends battery through the upper winding of line relay A, break contacts on the release magnet and on relays F and R, winding 1-2, and thence through the toll board circuits to winding 3-4 and break springs on relay R to ground. Relay A operates to close the circuit of release relay B.

Relay B operates, (1) places ground on the release trunk C to make this switch busy, (2) closes the upper winding of relay C by way of break springs VON (vertical off-normal), and (3) closes the circuit of relay J (Fig. 2) by way of break springs relay R, CAM (operates on the 11th rotary step), and relay S.

Relay C operates to shunt windings 1-2 and 3-4 of the repeating coil, in order to facilitate dialing.

Relay J operates, but without effect at this time.

(B) Vertical Stepping: (Operated; relays A, B, C and J). Line relay A follows the dialing impulses from the toll board. Relay A restores and operates (on each dial impulse); (1) opens and closes the circuit of relay B, and (2) closes and opens the circuit to the vertical magnet VM, in parallel with the lower winding of relay C, by way of contacts on relays S and B. Slow to release relay B remains operated during pulsing.

Vertical magnet VM operates and steps the wipers to the desired level. On the first vertical step, the VON springs operate to, (1) close the circuit of relay L by way of contacts on RM, CAM, and relays S and B, and (2) opens the upper winding of relay C.

Relay L operates, (1) to prepare the circuit of rotary magnet RM, and (2) to shunt the cam springs.

After the last pulse, relay A re-operates, again closes the circuit of relay B, and opens the circuit of the vertical magnets and the lower winding of relay C.

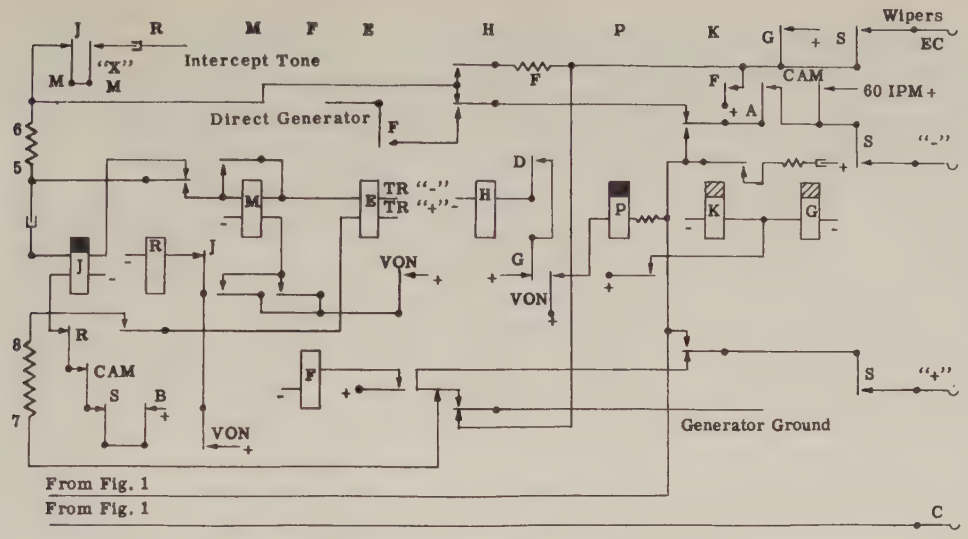



Fig. 2 - Toll Transmission Selector, Right Half.

Automatic Rotary Searching: (Operated; relays A, , J, L and VON).

ay C restores after a short delay, (1) removes the nt from the repeating coil windings, and (2) closes circuit of the rotary magnet by way of contacts on y L. The rotary magnet operates, step the wipers to first contact and opens the circuit of relay L. Relay L ores and opens the circuit to RM, which restores.

ne event that private wiper C (Fig. 2) fails to find istance battery on the first contact in the level, ay L will re-operate and again close the circuit M. The rotary magnet re-operates, steps the wipers e next contact and again opens the circuit of relay L. cycle will continue until, (1) an idle trunk is found, 2) the wipers reach the 11th rotary step. This is ned A.T.B., (all trunks busy).

A.T.B., "Flash Busy": (Operated; relays A, B, J, RM and VON). If all trunks are busy on the dialed 1, the wipers are rotated to the 11th rotary step. CAM springs operate to, (1) open the circuit to y L, preventing its re-energization when the rotary net restores, (2) open the lower winding of relay L . 2) and, (3) prepares a circuit to extend 60 I.P.M. ulses per minute) ground pulses.

ay J restores to close the circuit of relay R.

y R operates, (1) closes a circuit through the upper ling of relay E in series with the upper winding of y M, make springs relay R, winding 5-6, break ngs relays H and K, make springs relay A, through M to 60 IPM ground pulses, and (2) reverses the ery feed to the toll board (Fig. 1), thus causing the rvisory lamp to light at the toll board. Note that the r winding of line relay A is now connected via break ngs release magnet, break springs relay F, make ngs relay R, winding 4-3 to the "+" line, while the line is connected via winding 2-1, make springs relay R, break springs relays G, F and H, through the lower winding of line relay A and VON to ground.

Relay M operates on the first ground pulse to, (1) lock its lower winding through VON to ground, and (2) short circuit its upper winding.

Relay E operates and restores 60 times per minute, closing and opening the circuit of relay F.

Relay F operates and restores 60 times per minute to, (1) provide a holding circuit for line relay A (Fig. 1) which may be traced from upper winding relay A, break springs RLSE magnet, resistor E, make springs relay F, break springs relay H through the lower winding of relay A to ground at make VON springs, and (2) removes battery feed relay A from the line leads, thus causing the supervisory lamp at the toll board to be flashed 60 times per minute.

(E) Seizing First Idle Trunk: (Operated; relays A, B, J, also RM and VON). When an idle trunk is encountered, resistance battery on the C wiper closes a circuit through the lower winding of relay S (Fig. 1) to ground at the springs of relay B.

Relay S operates, (1) opens the circuit to relay L to prevent its further operation and locks its upper winding by way of make springs VON and make springs relay B, (2) shunts out its lower winding (to operate a relay in the switch ahead), (3) closes the trunk loop by way of "-" wiper (Fig. 2), make contacts on relays S and A, break contacts relays K and H, winding 6-5, break contacts relay R, upper winding relay J, winding 4-3, break contacts relays H and K and make contacts relay S to the "+" wiper, (4) opens the circuit to the lower winding of relay J, and, (5) and closes the upper winding of relay C (Fig. 1) by way of make springs on relay J and VON.

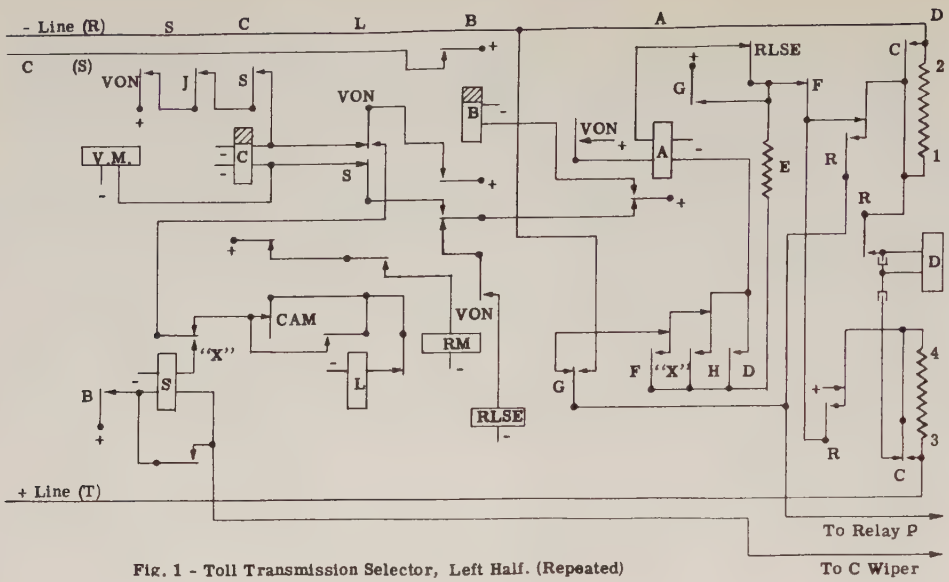



Fig. 1 - Toll Transmission Selector, Left Half. (Repeated)

Relay C again operates to shunt out the repeating coil windings 1-2 and 3-4 as an aid to dialing.

(F) Completing the Connection: (Operated; relays A, B, C, J, S and VON). Relay A follows further dial pulses from the toll board, restoring and operating with each pulse, and opens and closes the trunk loop thus stepping the switches ahead to extend the connection to the called party.

(G) Line Seizure Supervision: (Operated; relays A, B, C, J, S and VON). When the dialed line is seized by the connector (toll or combination), that switch opens the trunk loop to cause the de-energization of relay J (Fig. 2).

Relay J restores, closes the circuit of relay R, and opens the upper winding of relay C.

Relay R operates, (1) prepares the battery feed to the called party by (a) extending the "-" wiper by way of contacts on relays S, A, K, H, winding 6-5, make springs relay R, upper winding relay M and through the upper winding of relay E to transmission battery, and (2) extending the "+" wiper by way of contacts on relays S, K, H, winding 3-4, make springs relay R, to transmission ground through the lower winding of relay E, (3) closes relay D (Fig. 1) across the line loop in series with a condenser, and (4) reverses polarity to the toll board as an indication of line seizure supervision.

Relay C restores and removes the shunt from the repeating coil windings.

(H) Called Line Busy: (Operated; relays A, B, C, J, S and VON). If the called line is busy; the connector opens the trunk loop and extends 120 IPM ground pulses to the "-" wiper (Fig. 2). The opening of the trunk circuit causes relay J to restore.

Relay J restores, closes the circuit of relay R and opens the circuit of relay C.

Relay R operates, (1) closes the "-" wiper to the upper windings of relays M and E in series, and (2) reverses the battery polarity over the line leads causing the supervisory lamp to light at the toll board. The 120 IPM ground pulses from the connector close and open the circuit to the upper winding of relay E one hundred and twenty times per minute and the operation of relays E and F return flash busy to the operator as described in Section (D) above.

(I) Ringing the Called Line: (Operated; relays A, B, R, S and VON). In order to ring the called line, the operator momentarily actuates a ringing key which impresses ringing current on the "-" and "+" line conductors. This passes from the "-" line through the 2-1 winding, relay D in parallel with a condenser, a series condenser and the 4-3 winding to the "+" line.

Relay D operates, (1) provides a holding circuit for line relay A by way of resistor E, and (2) closes the circuit of relay H (Fig. 2) by way of break springs on relay G.

Relay H operates, (1) removes generator ground from the EC wiper, and (2) closes a multiple holding circuit for relay A (Fig. 1).

Removal of ground from the EC wiper causes the connector to start the automatic ringing of the called line.

Release of the ringing key stops the current flow through relay D, which restores and opens the circuit of relay H. Relay H restores, (1) replaces generator ground on the EC wiper, and (2) removes the holding circuit of relay A.

(J) Answering: (Operated; relays A, B, R, S and VON). When the called party answers, talking battery will be supplied through the two windings of relay E. Relay M shunts itself out of the circuit as previously explained, and relay E operates to close the circuit of relay F.

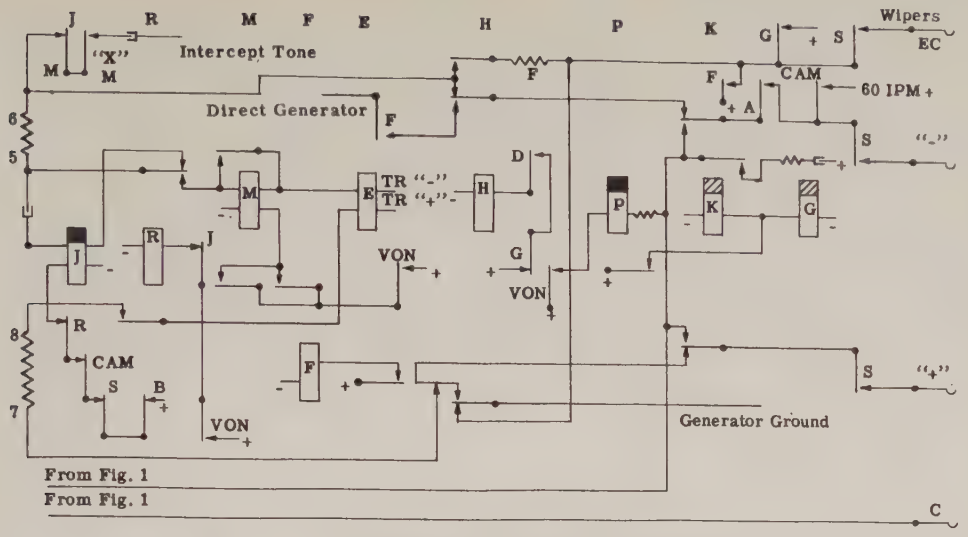



Fig. 2 - Toll Transmission Selector, Right Half. (Repeated).

y F operates, (1) closes a multiple ground to the EC r, (2) closes the holding circuit of relay A, and emoves battery feed relay A from the line circuit, thus ng disconnect supervision. This is an illustration "dry trunk".

e frequency currents are transmitted through the ating coil from windings 5-6-7-8 to winding 1-2-3-4 nduction. Transmission battery to the trunk is lied by toll grade transmission battery through the lay.

Disconnect Supervision: (Operated; relays A, B, E, , M, S and VON). When the called party restores his l set to the cradle, the loop circuit from relay E is ed. Whereupon relay E restores and opens relay F.

y F restores to reconnect relay A to the calling line. reversed polarity (relay R is operated), causes the rvisory lamp to light and give disconnect supervision e toll operator.

Re-Ringing the Called Line: (Operated; relays A, R, M, S and VON). Should the operator wish to ing the called party, she may do so by again operating ringing key, thus placing ringing current on the line nergize relay D.

ay D operates, closes the circuit of relay H, and es the holding circuit of relay A.

y H operates, (1) removes the 5-6 and 7-8 repeating windings from the trunk, (2) removes generator nd from the EC wiper and connects battery thereto vay of the upper winding relay E, make springs ys M and R, winding 5-6, make springs relay H, stor F, and make springs relay S, and (3) closes a iple holding circuit to relay A (Fig. 1).

oval of ground from the EC wiper causes a ringing y in the connector to operate and re-ring the called line. Relays D and H restore when ringing current is removed from the line leads.

(M) Re-Ringing a P.B.X. Trunk: (Operated; relays A, B, E, F, R, M, S and VON). If the called number is a P.B.X. trunk (or a similar bridged circuit), relay E does not restore when the called party restores his hand set to the cradle since relay E is held operated by the bridge. Therefore, relay F also remains operated. When the toll operator actuates her ringing key, relay D operates to close the circuit to relay H.

Relay H operates, (1) places direct generator on the "-" wiper by way of contacts on relays S, A, K, H and F, and (2) connects generator ground to the "+" wiper by way of contacts on relays S, K, and H.

Relays D and H restore as before when the operator opens the ringing key.

(N) Release From Completed Connection: (Operated; relays A, B, E, M, F, R, S and VON). When the called party restores his hand set, thus opening the trunk loop, relay E restores and opens the circuit of relay F.

Relay F restores, re-connects relay A to the line circuit (Fig. 1), and opens the holding circuit to relay A. The toll operator now receives disconnect supervision as explained in Section (K) above.

When the toll operator withdraws the plug from the associated jack, relay A restores to open relay B.

Relay B restores, (1) removes ground from the C lead to release the preceding switches (when used), (2) removes ground from the C wiper to release the connector, (3) opens the upper winding of relay S, and (4) closes the circuit to the release magnet by way of operated VON springs.

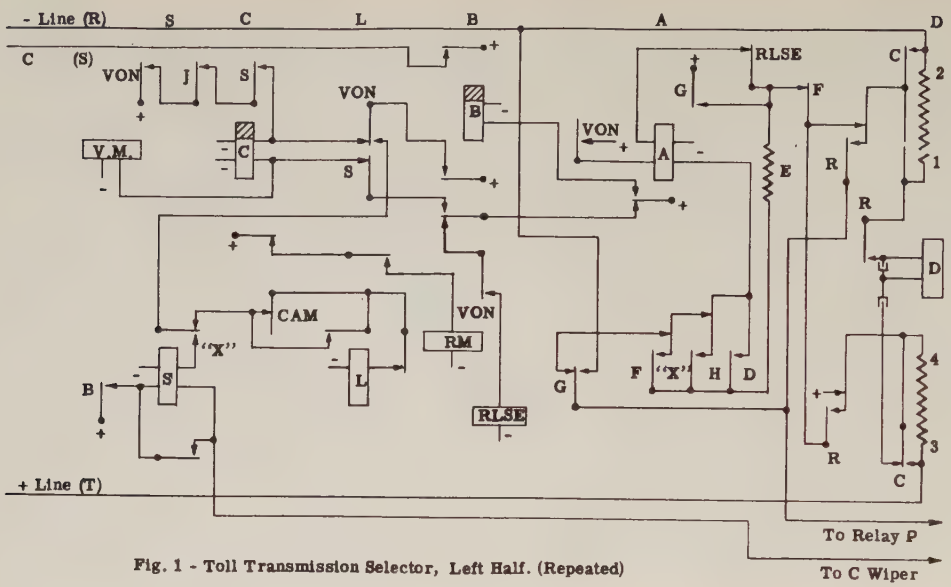



Fig. 1 - Toll Transmission Selector, Left Half. (Repeated)

Relay S restores and the release magnet operates to return the switch to normal, thus opening the circuit of the release magnet and relays R and M.

(O) Release From A Busy Condition: (Operated; (1) relays A, B, M, R, and E and F intermittently, also CAM and VON, if from an A.T.B. condition, and (2) relays A, B, M, R, S, and E and F intermittently, also VON, if from a called line busy condition). When the toll operator receives the "flash busy" signal, she withdraws the plug from the associated jack to open the circuit of relay A and cause the release of the switch train.

(P) Intercept Service: (Operated; relays A, B, R, S and VON). If the called line is no longer connected, the circuit is extended to an "intercept" operator's position. The intercept operator is signalled and, upon answering, closes a high resistance bridge across the "-" and "+" wipers. This high resistance bridge closes the circuit of the upper windings of relays M and E. Relay E will not operate at this time, but relay M will close its "X" contacts only, thereby extending "intercept tone" to the intercept operator so that she will recognize that the incoming call is from the toll board. (The operation of relay M is a very clever circuit kink - make note of it).

To complete the talking circuit, the intercept operator removes the high resistance bridge. Relay E then operates and closes the circuit of relay F. Relay M operates fully, locks its self up and removes intercept tone from the "-" wiper. Relay F operates and the rest of the talking circuit is completed as described in Section (J) above.

(Q) Coin Control: (Operated; relays A, B, M, F, R, S (also E and F if the called party still has the hand set removed), also VON). For coin control, the toll operator places 110 volt D.C. "coin control voltage" on the "-" line to operate relay P by way of winding 2-1, break springs relay R, a limiting resistance (Fig. 2), through relay P to ground at VON. Relay P operates to close the circuits of relays K and G in parallel.

Relay G operates, (1) places ground on the upper winding of relay A (Fig. 1) by way of break springs on the release magnet, (2) shunts winding 2-1, and (3) opens the circuit to the lower winding of relay A.

Relay K operates, (1) to remove battery feed relay E from the trunk, and (2) extends the 110 volt coin control voltage to both the "-" and "+" wipers by an obvious circuit. The circuit of the coin control voltage is completed via the earth, the polarity of the application determines whether the coin will be collected or returned.

When the 110 volt D.C. is removed from the line, relay P restores and opens the circuit to relays K and G. Relays K and G restore, re-closing the trunk circuit to battery feed relay E. Relays E and F re-operate if the called party is still on the line.

(R) Recapitulation: (1) The polarity of the line, when the TTS (toll transmission selector) is seized, is such that the supervisory lamp at the toll board is dark. (2) When the connector seizes the dialed line, it opens the trunk loop from the TTS, whereupon the line polarity is reversed and the supervisory lamp lights. (3) Actuation of the ringing key at the toll board starts the automatic ringing at the connector. The toll operator can hear the ring back tone. (4) When the called party answers, the TTS removes the battery feed from the line loop, thus producing a "dry trunk". The supervisory lamp is extinguished. (5) When the called party restores his hand set to the cradle, TTS reconnects the battery feed to the line loop, but with reversed polarity, therefore the supervisory lamp again lights. (6) When the TTS finds all trunks busy, it removes reversed polarity from the line sixty times per minute, thus causing the supervisory lamp to flash an indication of "all trunks busy". (7) When the connector finds the called line busy it opens

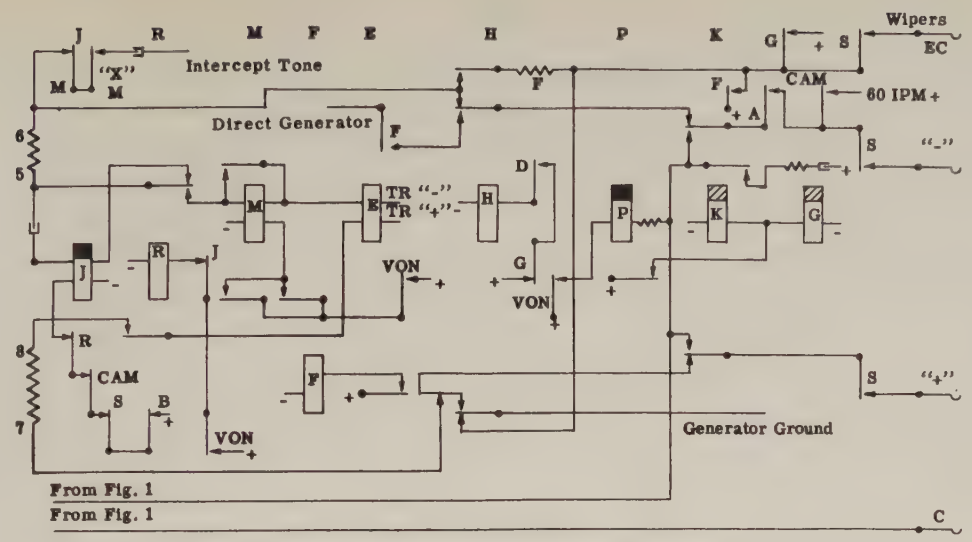



Fig. 2 - Toll Transmission Selector, Right Half. (Repeated).

ttrunk loop and places 120 IPM ground pulses on the wiper of the TTS, which removes reversed polarity m the line one hundred and twenty times per minute, causing the supervisory lamp to flash an indication "busy line" condition.

(b) Toll Connector: The toll connector was previously cussed in Section 216(b). Refer now to Figure 3

The operation of this switch is quite standard as far as the vertical and rotary movement is concerned, we will therefore pass directly to the testing of the called line.

(B) Testing the Called Line: (Operated; relays A, B, E and F). When the called line is busy, relay H operates from ground on the C wiper, see (G) below for circuit operation. We will now assume that the called line is

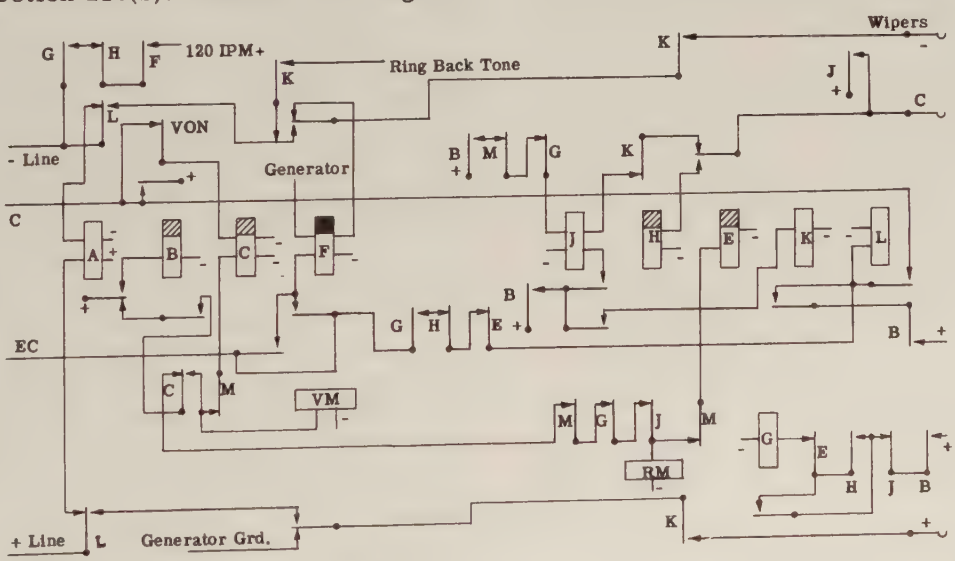



Fig. 3 - Toll Connector.

ch is a partial circuit of a Toll Trunk and Level ting Connector. Note that this circuit is marked by the presence of resistance battery on the C lead, break springs VON and upper winding of relay C.

Seizure: A loop on the "-" line and "+" line leads es the circuit of relay A. Relay A closes the circuit elay B, which (1) places ground on the C lead, and closes the upper winding of relay C. Relay C closes lower winding of relay F to ground on the EC lead, reupon relay F locks up to the same lead.

idle. Relay E restores after the series of pulses and extends resistance battery (B.C.O. of the called line) by way of break springs relays E and K, upper winding relay J, break springs relays G and M, to ground at make springs relay B.

(C) Called Line Free: (Operated relays A, B and F). Relay J operates, (1) locks its lower winding to make springs relay B, (2) closes the circuit of relay K, and (3) places direct ground on the C wiper.

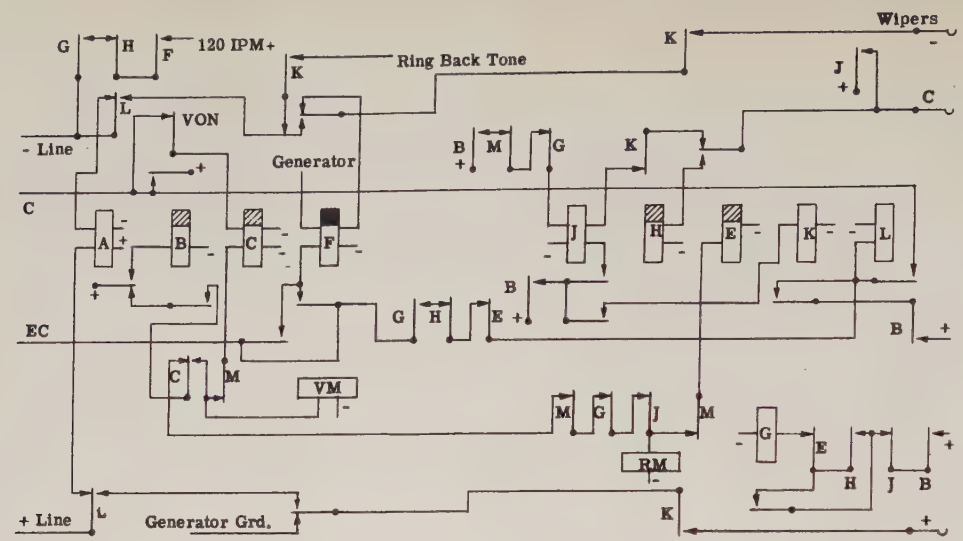



Fig. 1 - Toll Connector. (Repeated)

Relay K operates and closes the circuit to relay L by way of make springs on relay B.

Relay L operates, (1) locks up to incoming ground on the C lead, (2) connects the negative line to the "-" wiper via make springs relays K and F, and the positive line to the "+" wiper via make springs on the same relays, and (3) removes relay A from across the line, thus enabling the TTS (toll transmission selector) to return "seizure supervision" to the toll board.

Relay A restores and opens the circuit of relay B.

Relay B restores and removes a multiple ground from the C lead, but without effect as the incoming C lead is grounded at this time.

(D) Ringing and Ring-Back Tone: (Operated; relays F, J, K and L). The start of ringing is controlled by the toll operator. Automatic ringing is started when the TTS momentarily removes ground from the EC lead, thereby opening the circuit to the lower winding of relay F.

Relay F restores, (1) connects ring-back tone to the "-" line by way of contacts on relays L, F and K, (2) extends battery connected interrupted generator through its upper winding, via make springs relay K to the "-" wiper, and (3) extends generator ground via make springs relay K to the "+" wiper.

To re-ring on toll calls, the toll operator and the TTS function the same as for the initial ring.

(E) Called Party Answers: (Operated; relays J, K and L). When the called party answers, relay F operates in the usual manner to cut off the ring and, (1) extends the "-" line to the "-" wiper, and (2) extends the "+" line to the "+" wiper. At this time the TTS returns answer supervision to the toll board.

(F) Releasing: (Operated; relays F, J, K and L). When the called party hangs up, the toll operator receives disconnect supervision from the TTS. The release of this connector is controlled by incoming ground on the C lead.

(G) Called Line Busy: (Operated; relays A, B, E and F). When the called line is busy, the circuit of relay H is closed by way of make springs relay E to the C wiper. Relay H operates but without effect at this time. After the last impulse of the series, the circuit to relay E is opened.

Relay E restores; (1) closes the circuit to relay G via contacts on relays E, H, J and B, and (2) opens the circuit of relay H.

Relay G operates, (1) locks up independent of make springs on relay H, and (2) opens the circuit of relay J to prevent its operation should the called line become free.

Relay H restores, (1) places 120 IPM ground pulses on the "-" line by way of make springs relay G, break springs relay H, and make springs relay F, and (2) closes the circuit to relay L via break springs relays E and H, make springs relay G, to the EC lead.

Relay L operates, (1) locks itself to ground on the C lead, and removes relay A from the "-" and "+" line. Relay A restores and opens the circuit of relay B, which, in turn, also restores.

The removal of battery feed from the "-" and "+" line leads, and the placing of 120 IPM ground pulses on the "-" line lead, causes the TTS to return a busy line indication to the toll board.

411(c) Combination Local and Toll Connector: The combination connector was discussed in Section 216(c). In Figure 2 of the present section is shown a typical circuit diagram. Official circuit drawings are intended primarily for use in manufacture, therefore they show

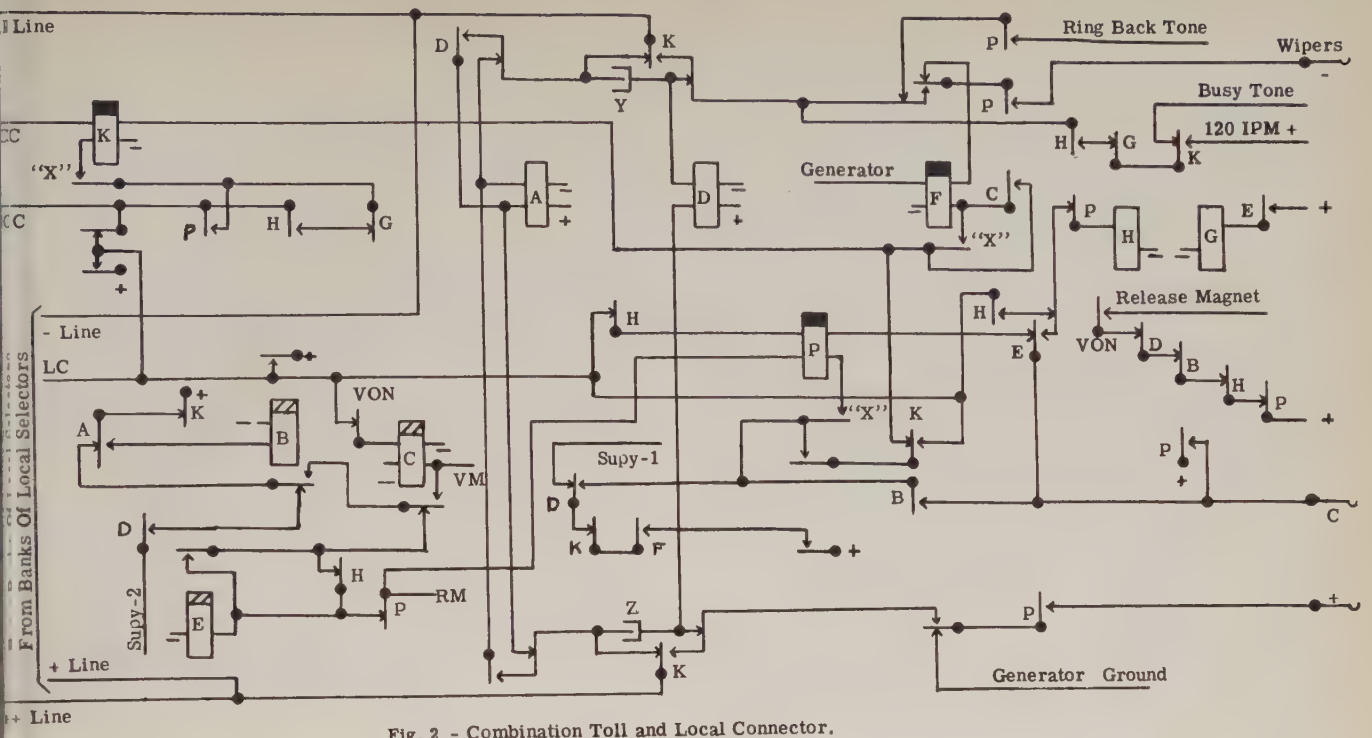



Fig. 2 - Combination Toll and Local Connector.

ny details that need not be considered by the student in gaining general knowledge of circuit operation.

scheme here used, employing both attached and ached contacts, makes for a simple diagram which can readily comprehended. The student, before attempting read the circuit, should be sure to understand "break, ke-before-break" spring combinations as used on ays E, F and K. These are just one step more plicated than the "make-before-break" combinations d on relay D to reverse the polarity of the battery d to the calling line.

member the basic connector circuit. A calling line, battery by a line relay. A called line, fed battery by ack bridge relay. And a pair of condensers that join two circuits. In the figure, the "talk through" densers are Y and Z. The line relay is A, and the k bridge is D.

te that this circuit is marked free, in the banks of her switch train, by battery through upper C, break N springs, to the LC (local C) lead or, in the case of (toll C), by way of break springs on K.

Local Seizure: Relay A operates to close B. Relay B erates, (1) to place ground on both C conductors to make s switch busy to other calls, and (2) closes upper C. lay C operates to prepare various circuits.

Vertical Stepping: (Operated; relays A, B and C). lay A restores on each dial pulse, opens B and closes ver C and the vertical magnet.

e vertical magnet operates on each pulse from A, ises the shaft mechanism and wipers one step for each al pulse, and operates the VON springs on the first rtical step. Relays B and C remain operated during e vertical stepping.

Relay C restores after the completion of the first series of dial pulses, and transfers the pulsing circuit to E and rotary magnet.

(C) Rotary Stepping: (Operated; relays A, B, also VON). Relay A follows the second series of dial pulses, (1) opens and closes B, and (2) closes and opens E and the rotary magnet.

Relay E operates on the first pulse, (1) closes G, (2) extends the C wiper to H, and (3) locks up independent of break springs on H. (Relay H will operate during rotation if the C wiper passes over grounded contacts).

Relay G operates, but without effect at this time. The rotary magnet operates on each pulse from A, and rotates the shaft and wipers over the contacts of the dialed level - one step for each dial pulse.

Slow to release relay E remains operated during the rotary stepping, and will remain operated for an interval after the completion of the second series of dial pulses. It is during the above mentioned interval that the busy test is made.

(D) Called Line Busy: (Operated; relays A, B, E, G, also VON). If the called line is busy, the C wiper will extend ground from the C bank contact of the called line to H.

Relay H operates, and opens the circuit of the release magnet to prevent a premature release. No further action takes place until E restores.

Relay E restores, (1) opens the circuit of G, and (2) transfers H from ground on the C wiper to ground on the release trunk (C lead). This connector is now independent of the condition of the called line.

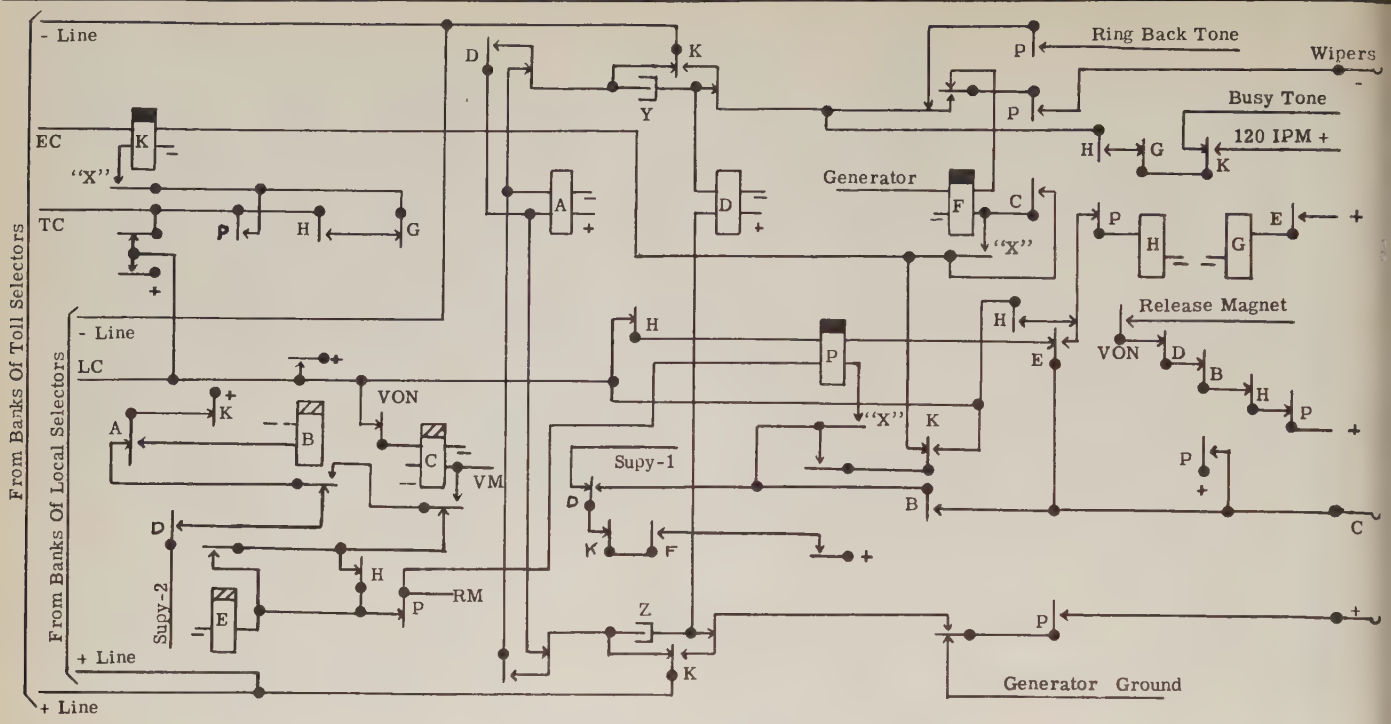



Fig. 1 - Combination Toll and Local Connector. (Repeated)

Relay G restores and extends busy tone to the calling party.

(D1) Called Line Idle: (Operated; relays A, B, E, G, also VON). If the called line is idle, the C wiper will encounter resistance battery (BCO of the called line), which will afford no circuit for H.

Relay E restores, after a slight delay, opens the circuit to G, and transfers the wiper from H to the upper winding of P, and thence to release trunk ground.

Relay G restores, but without effect.

Relay P operates in series with the BCO of the called line, (1) closes its "X" contacts first, thereby connecting its two windings in series (battery through rotary magnet, lower winding P and its "X" contact, make springs relay B, break springs relay E, upper winding relay P, break springs H, to release trunk ground at springs of B, a neat circuit kink) and becomes fully operated, (2) extends ringback tone to the calling line through condenser Y, (3) impresses ringing current on the called line by way of upper F, (4) opens further the rotary magnet circuit (thus preventing further rotation), and (5) places ground on the C wiper to operate the BCO of the called line, thus clearing it of attachments.

(E) Answering: (Operated; relays A, B, P, and VON). When the called party answers, a direct current flow through the upper winding of ring cut-off relay F will cause its partial operation.

Relay F closes its "X" contacts first, thus energizing its lower winding, becomes fully operated, (1) removes ringing current from the called line, (2) closes the called loop through back bridge relay D, (3) removes ringback tone from the calling line, and (4) closes ground to the Supy-1 lead.

Relay D operates, (1) reverses polarity over the calling loop for metering or supervisory purposes, (2) removes ground from the Supy-1 lead, and (3) completes a holding circuit for lower P which is independent of B.

(F) Transmission: (Operated; relays A, B, P, F, D and VON). During conversation, voice frequency currents flow through this circuit by way of the "-" and "+" line leads, condensers Y and Z, and the "-" and "+" wipers. The calling line receives talking battery through line relay A, and the called line receives talking battery through back bridge relay D.

(G) Releasing: This is a "last party" release connector, for prior discussion see Section 205(p).

(G1) Calling Party Releases First: (Operated; relays A, B, P, F, D, and VON). When the calling party restores his handset first, the loop to A is opened. Relay A restores, opens B and closes E. Relay E operates and closes G. The energization of E and G at this time is without effect, they will restore when relay B restores.

Relay B restores, (1) removes ground from the C lead to release preceding switches, (2) places ground on the Supy-2 lead to give calling party disconnect supervision, and (3) opens the circuit of E and G.

Relay E restores and replaces guarding ground on the C lead by way of springs on H, upper P, break springs E, and make springs P. Note the unguarded interval between the restoration of B and the restoration of E. This interval permits the release of all preceding switches. This switch is now held by the called party, and tests busy in the banks of preceding switches. The Supy-2 alarm is sounding which will bring an attendant if the called party does not restore his handset within a reasonable length of time. When the called party restores his handset, the loop to back bridge relay D is opened.

ay D restores, (1) returns normal polarity to the ing line, (2) opens P and F, and (3) removes ground n the Supy-2 lead.

y P restores, (1) removes ground from the C wiper, freeing the called line, and (2) closes the release net. Relay F restores without effect.

ease Magnet operates to restore the shaft, wipers, and springs to their normal position. At normal, the springs open the circuit of the release magnet. The uit is now at normal and may receive another call.

Called Party Releases First: (Operated; relays A, , F, D, also VON). When the called party restores his set first, the loop to D is opened.

ay D restores, (1) returns normal polarity to the ng line, (2) opens P and F, and (3) places ground on Supy-1 lead to give called party disconnect super- on. The Supy-1 alarm is now sounding, which will g an attendant if the calling party does not restore handset within a reasonable length of time. When the ng party restores his handset, the loop to line relay opened.

ay A restores, and the release of the connection ws in the usual manner.

Release From a Busy Line: (Operated; relays A, H, and VON). The calling party, upon hearing the y tone, restores his handset to open the loop to A.

ay A restores, and the release of the connection ws in the usual manner.

Release From an Abandoned Call: (Operated; ys A, B, P, and VON). If the called party does not wer, the calling party will restore his handset to open loop to A. Relay A restores and the release of the nection follows in the usual manner.

Toll Seizure: Seizure is the same from the toll ector banks as from the local selector banks, except incoming ground on the EC lead passes by way of er K, make springs on C to battery through lower F.

ay K operates partially to make its "X" contacts only.

ay F operates fully, note that its "X" contacts shunt ak springs on C.

Vertical Stepping: (Operated; relays A, B, C, F, and tially K). Vertical stepping is the same as explained ve.

Rotary Stepping: (Operated; relays A, B, F, and tially K, also VON). Rotary stepping is the same as lained above.

Testing the Called Line:

) Called Line Busy: (Operated; relays A, B, E, G, F, partially K, also VON). The called line busy test is same as explained above except, when relay G ttores (remember that H has just operated), a circuit is closed to lower K by way of contacts on K, G, and H and thence to incoming ground on the toll C lead.

Relay K operates fully, (1) places direct ground on the local C lead, (2) removes relay A from the line loop, and (3) cuts talking condensers Y and Z, also relay D, out of the transmission circuit, (4) extends 120 IPM ground pulses to the "-" line, and (5) opens B.

Relay B restores to remove ground from the local C lead, but without effect. Relay A restores, but without effect.

The ground pulses on the negative line cause a supervisory lamp at the toll board to flash an indication that the called line is busy.

(K2) Called Line Idle: (Operated; relays A, B, E, G, F, and partially K, also VON). If the called line is idle, the operation is the same as explained above except, (1) the ringing and ringback circuits are now open because F is operated, and (2) the operation of P energizes lower K.

Relay K operates fully, (1) places direct ground on the local C lead, (2) removes A from the line loop, which causes a supervisory lamp to give "seizure supervision" at the toll board, and (3) opens B.

Relay B restores to remove ground from the local C lead, but without effect. Relay A restores, also without effect.

(L) Ringing the Called Line: (Operated; relays F, K, P, also VON). Ringing the called line is under the control of the toll operator. Actuation of her ringing key causes ground to be removed from the EC lead, thus opening lower F.

Relay F restores, (1) applies ringing current to the called line, and (2) closes ringback tone to the "-" line as an indication to the operator that the called line is being rung.

(M) Answering: (Operated; relays K, P, also VON). When the called party answers, a direct current passes through lower F. Relay F operates as explained above.

(N) Transmission: (Operated; relays K, P, F, also VON). Voice frequency currents pass through this circuit over the "-" line and "+" line leads and the "-" and "+" wipers during conversation.

(O) Re-Ringing: The toll operator can re-ring the called line after the called party restores his receiver, by momentarily removing ground from the EC lead. Relay F will operate as above explained.

(P) Releasing: (Operated; relays K, F, P, also VON). When the toll operator disconnects, ground is removed from the toll C lead and the EC lead, thus opening K and F.

Relay K restores, (1) removes ground from the local C lead, and (2) opens lower P. Relay P restores, (1) removes ground from the C wiper, and (2) closes the circuit of the release magnet. The release of the switch follows in the usual manner.

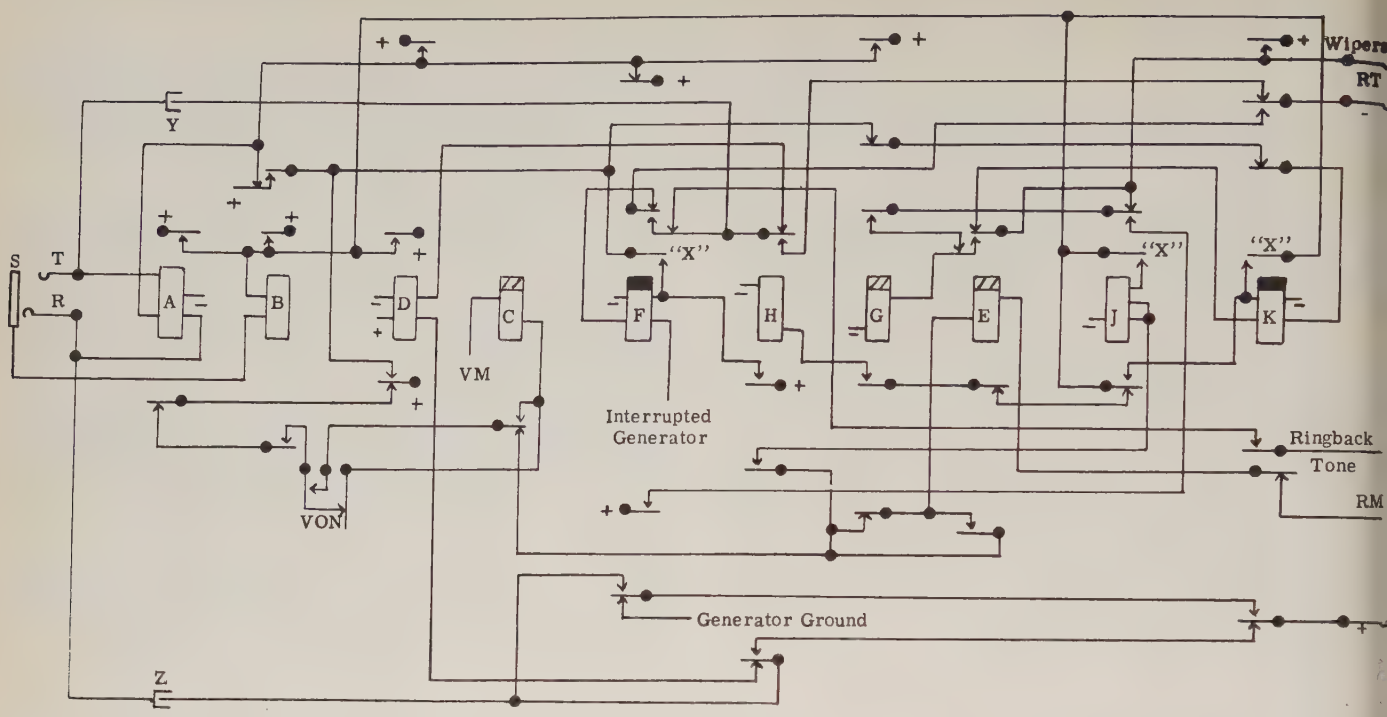



Fig. 1 - Individual Toll Connector.

411(d) Individual Toll Connector: When the traffic so warrants, trunks from the toll board may terminate directly on toll connectors. When the operator at the toll board inserts a plug into the jack of Figure 1, a loop is closed to line relay A, and resistance battery is placed on release relay B.

Relay A operates and closes relay B. Relay B operates, (1) locks itself up, and (2) prepares the circuit to relay C and the vertical magnet.

(A) Vertical Stepping: (Operated; relays A and B). Relay A follows the pulses of the first series. The first time relay A falls away, a circuit is extended from break springs relay D, break springs relay A, make springs relay B, break springs VON, through relay C to the vertical magnet.

Relay C operates to prepard its locking circuit. The vertical magnet operates on each pulse of the series and raises the shaft and wipers to the desired level. The VON springs operate at the first vertical step and direct the remaining pulses to relay C by way of its locking contact. Relay C remains operated throughout the series, then restores and directs the impulsing circuit to relay E and the rotary magnet.

(B) Rotary Stepping: (Operated; relays A, B, also VON). The second series of impulses passes, by way of break springs on relay C, break springs busy relay G, through relay E to the rotary magnet.

Relay E operates, (1) opens a part of the incomplete circuit to the lower winding of relay K, so that relay K will not operate to open the impulsing circuit when the RT wiper passes over idle lines, (2) connects relay G to the RT wiper, (3) shunts break springs on relay G so that the impulsing circuit will not be opened when relay G operates as the RT wiper passes over busy lines, and (4) opens part of the incomplete circuit to relay H, so that relay H will not operate when relay G energizes as the RT wiper passes over busy lines. The rotary magnet advances the shaft and wipers to the called line.

(C) Called Line Busy: (Operated; relays A, B, E, also VON). If the called line is busy, relay G is closed from ground on the RT wiper.

Relay G operates, (1) places a multiple ground on the lower winding of relay A, (2) opens part of the incomplete circuit to relay E and the rotary magnet, so that this switch will not advance when the circuit to relay A is again interrupted, and (3) opens part of the incomplete circuit to the lower winding of relay K.

Relay E restores after the second series of impulses, (1) completes a locking circuit to relay G, so that relay G cannot restore until the called line becomes idle, and (2) closes relay H.

Relay H operates, (1) extends talking conductors T and R, by way of condensers Y and Z to the "-" and "+" wipers, and (2) closes the upper winding of relay F.

ay F operates, (1) locks itself up, (2) removes a tiple ground from the lower winding of relay A, and opens the ringing circuit to the called line.

toll operator hears the conversation on the busy line may decide, (1) to "camp on busy", or (2) to "offer" toll call.

Camp On Busy: (Operated; relays A, B, G, H, F, VON). When the called line becomes idle, ground is moved from the RT wiper and relay G.

ay G restores, (1) opens relay H, (2) closes the lower ding of relay K to the RT wiper and resistance battery O of the called line), and (3) removes the remaining und from the lower winding of relay A.

ay H restores, (1) disconnects the called line from the ing circuit, and (2) opens the starting circuit to ay F.

ay K operates, (1) locks its upper winding, (2) opens its rting circuit, (3) places direct ground on the RT wiper make the called line busy, and (4) opens the incomplete cuit of the rotary magnet so that it will not operate if ay A again restores.

) Ringing Called Line After "Camping On Busy": erated; relays A, B, F, K, also VON). The removal of und from the lower winding of relay A caused the toll rator to receive supervision indicating that the called e had become idle. The operator now momentarily uses resistance battery to be removed from the sleeve, s opening the circuit of relay B.

lay B restores and opens the upper winding of relay F.

lay F restores, (1) connects ring back tone to the king circuit, (2) connects the "-" wiper to interrupted ttery connected generator through the lower winding of lay F, (3) connects the "+" wiper to generator ground, d (4) replaces ground on the lower winding of relay A, give the toll operator supervision indicating that the lled party has not yet answered.

nen the handset at the called station is removed, the sulting direct current flow through the lower winding of lay F causes its "X" contacts to make.

lay F becomes fully operated, (1) removes generator rrent from the called line, (2) removes ring-back tone m the talking circuit, (3) bridges relay D across the p to the called line, and (4) removes ground from the wer winding of relay A to give the toll operator answer- g supervision.

Relay D operates, (1) replaces ground on the lower winding of relay A, (2) places a multiple ground on the locking winding of relay K, and (3) places a multiple ground on the locking winding of relay F.

Transmission battery is supplied to the called line through relay D.

(E) Toll Offering: (Operated; relays A, B, G, H, F, also VON). Should the operator wish to cut through to the busy line before it becomes idle, she may do so by dialing the digit one. Relay A falls away on the pulse and closes a circuit to the lower winding of relay J.

Relay J operates its "X" contacts only and, when relay A restores after the single pulse, the two windings of relay J are energized in series. Make note of this circuit device - it is very useful.

Relay J operates completely, (1) transfers the locking circuit of relay G to a contact on relay F, (2) opens the circuit of relay H, and (3) closes the upper winding of relay K. Relay K operates as previously explained.

Relay H restores, (1) opens the operating circuits to relays J and F, and (2) connects relay D to the called line.

Relay D operates as previously explained and the conversation takes place.

412 The Test Switch Train: The test switch train is another subject concerning which the student should have a general knowledge of many things before he undertakes the circuit study of any one part. It is suggested that the student re-read Section 217; also Section 293(c) Outgoing Trunk to Test Distributer.

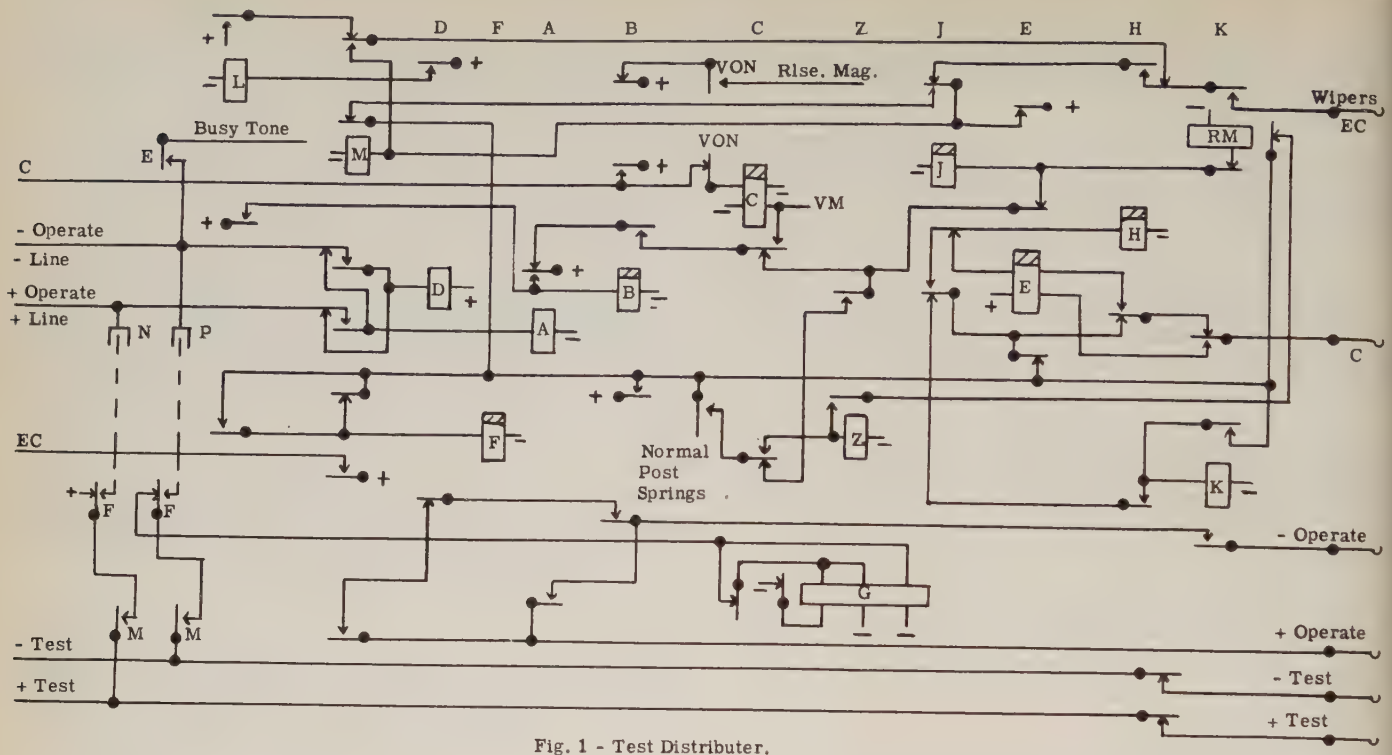



Fig. 1 - Test Distributer.

412(a) The Test Distributer: The test distributer shown in Figure 1 is normally a "two digit" switch, i.e., both the vertical and rotary movement is dial controlled. To save the testman some dial twirling, an automatic "cut-in" may be obtained on certain levels (or on all levels).

Do not confuse with "automatic selection of trunks", as performed by a selector. This cut-in merely kicks the wipers in one step on the level, irrespective of the condition of the first trunk. The automatic cut-in will take place on any level that operates the "normal post" springs. See Section 203 for explanation of normal post springs. The following discussion will assume that the test distributer is being operated as a "one digit" switch.

(A) Seizure: This switch may be seized from several different sources; (1) Direct from the test desk only, over leads "- Operate", "+ Operate", "EC", "- Test", and "+ Test", (2) From test distributer selector only, over leads "C", "- Operate", "+ Operate", "EC", "- Test", and "+ Test", (3) Direct from verification position only, over leads "- Line", "+ Line", and "EC", (4) From verification selector only, over leads "C", "- Line", "+ Line", and "EC", (5) From both test desk and verification position, over leads "- Operating", "+ Operating", "EC", "- Test", and "+ Test" (to test desk), and "- Line", "+ Line", and "EC" (to verification position).

This switch is marked free in the banks of preceding battery searching selectors (when used) by battery through the upper winding of relay C.

When this switch is seized, relays A and D are energized in series over the line. Relay A operates to close B. Relay D operates to close L, which operates to (1) close a secondary ground to B and (2) closes F. Relay B operates, (1) closes upper C and grounds the C lead to make this switch busy, and (2) locks up lower C.

(B) Vertical Stepping: (Operated; relays A, D, B, C, L, and F). Relays A and D follow the impulses of the first series. Relay A, at normal, closes lower C and the vertical magnet in multiple. The vertical magnet operates to raise the shaft and wipers to the dialed level. Slow to release relays B and C remain operated during pulsing. Relay L follows D, and maintains slow to release relay F operated during pulsing.

(C) Cutting-In on Dialed Level: (Operated; relays A, D, B, L, F, Z, also VON). Relay Z encounters ground when the normal post springs closed (it is assumed we called a "one digit" level). Relay Z operates (before C restores at the end of the first series), (1) closes its locking circuit, and (2) when C restores, closes J and the rotary magnet in parallel. Relay J operates and closes H. The rotary magnet advances the wipers to the first bank contact and opens the locking circuit of Z. Relay H operates and disconnects the test leads from the test wipers to prevent interference if the test connector is busy. Relay Z restores to open the circuit of J and the rotary magnet.

(D) Testing Trunk to Test Connector: (Operated; relays A, D, B, L, F, J, H, also VON). Relay J, upon restoring after its circuit was opened by Z, transfers the circuit of H from ground at B, to the C wiper, by way of upper E. This is the test for busy, see (K) below.

(D1) Test Connector Idle: (Operated; relays A, D, B, L, F, J, H, also VON). When the trunk is idle, relay J restores to open slow to release H and close K. Relay H

:cores to extend the test leads through to the test ers. Relay K operates, (1) locks up, (2) opens the rry magnet to prevent further rotation, (3) closes the k loop to the test connector over the operate wipers, (4) extends ground to the EC wiper.

Repeating Impulses: (Operated; relays A, D, B, L, , also VON). Relays A and D follow the impulses of wo succeeding series. Relay A at normal, opens the k loop and closes J.

ay J operates, and remains operated during each es, to close H. Relay H operates, (1) to again discon- the test wipers, and (2) removes ground from the wiper.

impulses repeated to the trunk loop cause the test nector to advance its wipers to the called line.

Called Line Busy: When the called line is found to be , the test connector returns ground to the EC wiper of test distributer. Relay J restores after the series, opens H, and (2) closes M from ground on the EC r. Relay M operates, (1) reverses battery on the line ive the testman a flashing busy signal, (2) locks up e EC wiper, and (3) returns ground on the EC lead.

Camp On Busy: The testman, on finding the called busy, can monitor (over the test conductors) to rmine if the line actually is in use. After monitoring may, (1) release the connection, (2) camp on the line l it becomes idle, or (3) if he is routine testing, step test connector to the next contact on the level by ing the digit one.

us assume that he camps. When the called line omes idle, ground is removed from the EC normal ciated therewith, and from the EC wiper of the test ributer. Relay M restores, (1) returns normal rity to the operating leads, whereupon the busy lamp e test desk burns steadily, and (2) replaces ground on EC wiper. Ground on the EC wiper causes the BCO of called line to energize and clear the line of attach- nts. The testman may now proceed to test the called by way of the test conductors.

Release of a "Permanent" Line: (Operated; relays 0, B, L, F, K, M, also VON). If the testman hears no versation, he may assume that the called line is rmanent". He then operates his "BCO" key to knock n the connection, in order that he may test to deter- e the short or ground that is causing the permanent. might be merely a "handset left off the cradle".

operation of the "BCO" key causes direct ground to laced on the "-" operating lead, thus shunting D. Relay D restores to open L. Relay L restores to open F. Relay F restores, (1) extends battery from the three windings of relay G in multiple (a resistance of approximately five ohms), to the negative test wiper, and (2) closes direct ground to the positive test wiper.

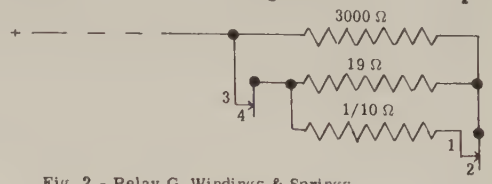



Fig. 2 - Relay G, Windings & Springs.

Note that relay G, Figure 2, is a reclosing circuit breaker. The two pairs of break springs open in sequence. If the current flow through the 1/10Ω winding is excessive, springs 1-2 break to remove the shunt from the 19 ohm winding. If the current is still excessive, springs 3-4 break to remove the shunt from the 3000Ω winding. If, at any step, the current flow is not sufficient to hold the relay, it will drop to the step below - and chatter. Another interesting Circuit Kink.

Refer to Figure 3 and note, (1) that the "permanent" line has been extended to line relay A of a first selector, and (2) relay B of the selector has returned holding ground to the finder and the BCO of the permanent line.

The placing of low resistance battery on the "-" test lead, and direct ground on the "+" test lead, shunts down operated relay A of the selector. The selector now releases and removes holding ground from the C lead, whereupon the finder releases and the BCO of the permanent line restores. The line relay of the called line is inoperative because of the shunt.

The release of the selector also removes ground from the EC wiper of the test distributer, as a result relay M restores to reclose F. Relay F operates to remove the permanent release battery and ground from the test leads. Relay M, upon releasing, restores ground to the BCO of the line under test by way of the EC wiper. The BCO of the called line operates to clear that line of attachments, and the testman may now test to determine the nature of the permanent.

If the resistance of the permanent is very low, the line relay of the selector will not be shunted down, and the permanent must be manually released before tests can be made.

(G) Called Line Idle: (Operated; A, D, B, L, F, J, H, K, also VON). When the called line is idle, relay J restores after the last series of impulses and opens H. Relay H restores, (1) connects the test leads through to the test wipers, (2) extends ground at L, via the EC wiper, to the EC lead of the test connector, to make the called line busy and clear it of attachments. The called line is now ready for testing.

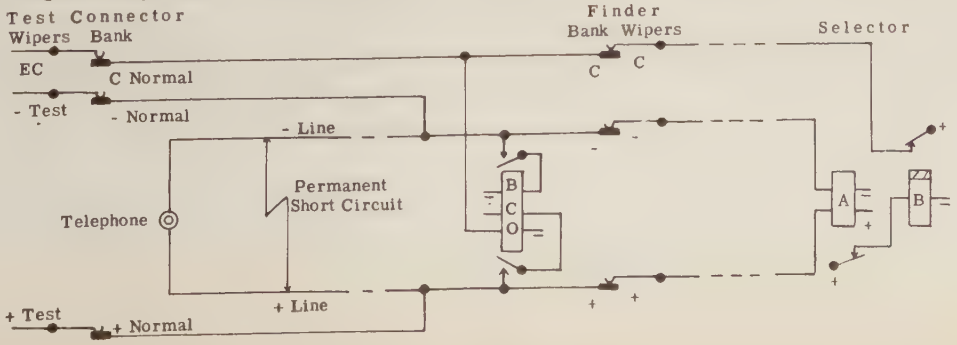



Fig. 3 - Illustration Of A Permanent Line.

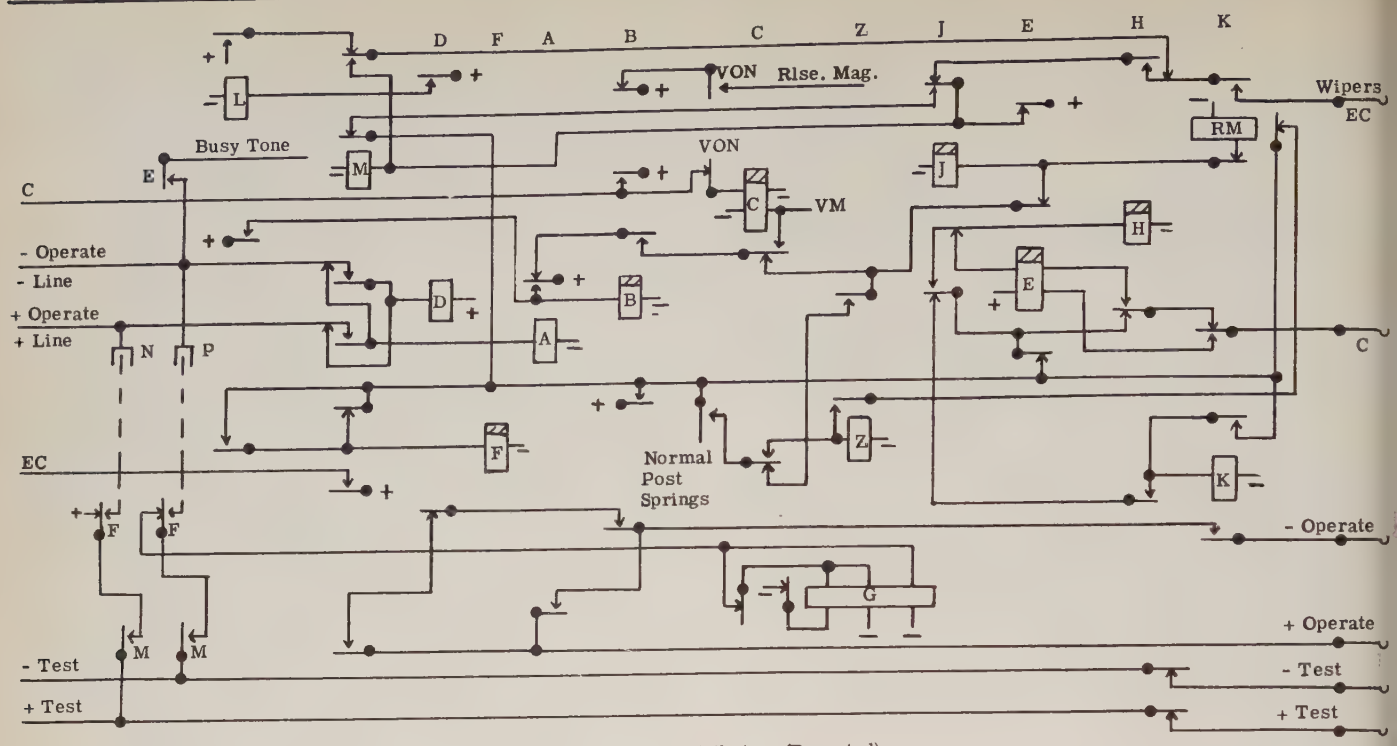



Fig. 1 - Test Distributer. (Repeated)

(H) "In" and "Out" Tests: An "out" test for grounded, crossed or open conductors may now be made. When the testman desires to conduct an "in" test (a test through the called line equipment) he operates his "BCO" key, thereby holding A operated and opening D. Relay D restores to open L. Relay L restores to open the BCO of the called line. The testman then operates his "Call Through" key to energize the line relay of the called line (over the test conductors), and proceeds to make the "in" test.

(I) Release of Test Connector Only: (Operated; relays A, D, B, L, F, K, also VON). When the testman desires to release only the test connector, he momentarily operates his "Connector Release" key. Battery through a resistance is placed on both operating leads, thereby holding D operated and shunts down A. Relay A restores and opens the trunk loop circuit to cause the test connector to release.

(J) Release of Entire Switch Train: When the testman desires to release the entire switch train, he disconnects, thereby opening the circuit of A and D. Relay D restores and opens L. Relay A restores, (1) opens the trunk loop circuit to allow the test connector to release, and (2) opens B. Relay B restores, opens K and closes the release magnet. The release magnet operates, allowing the shaft to return to normal and restores the VON springs.

(K) Dialed Test Connector Busy: (Operated, relays A, D, B, L, F, J, H, also VON). When the dialed test connector is busy, H is held operated from ground on the C wiper through the upper winding of E. Relay E operates, (1) opens an incomplete circuit to the rotary magnet to prevent further rotation should A again restore, (2) places busy tone on the line, and (3) closes M. Relay M operates, (1) reverses battery on the line to give the testman a visual busy signal, and (2) places ground on the EC lead. The testman thus receives both busy tone and the visual busy signal, indicating that the test connector is busy.

When the test connector becomes idle, removal of ground from the C wiper opens H and the upper winding of E. Relay E restores, (1) removes busy tone, and (2) opens M. Relay M restores to return normal polarity to the line. Relay H restores and connects the test leads through to the test wipers.

(L) Use of Connector Selector: When the switch under discussion (TD) is required to work into a test connector selector, instead of directly into a test connector (TC), it operates as previously explained - except when a busy switch is encountered.

When the dialed test connector selector is busy, the TD operates as explained above in Section (K).

When the dialed test connector (TC) is busy, the test connector selector connects battery to the C wiper of the TD, thereby closing the lower winding of E (relay K being operated).

Relay E operates, (1) places busy tone on the line, and (2) closes M. Relay M operates to reverse battery on the line and to place ground on the EC lead. The testman thus receives the busy tone and a visual busy signal.

When the TC becomes idle, the test connector selector opens the lower winding of E. Relay E restores, removes busy tone from the line and opens M. Relay M restores and returns normal polarity to the line.

(M) Verification Service: When this switch is used for verification service, the operating conductors are connected to the test conductors through talking condensers N and P.

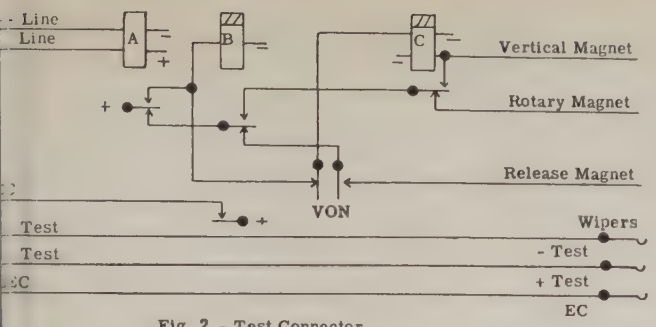



Fig. 2 - Test Connector.

(b) The Test Connector: Refer to Figure 2 and note this switch is marked free in the test distributer ks by the absence of ground on the C conductor.

Seizure: When the line loop is closed, relay A rates to close B and the upper winding of C. Relay B rates to ground the C lead, making this switch busy. y C operates, but without effect at this time.

Advancing the Wipers to the Called Line: (Operated; ys A, B, and C). For the vertical movement A follows ulses of the first series and, when at normal, closes lower winding of C and the vertical magnet. The ical magnet raises the shaft and wipers to the desired el. Relays B and C remain operated during the ical pulsing. The off-normal springs operate on the t vertical step to open the upper winding of C and pare the release magnet circuit.

r the last pulse of the vertical series, relay C ores to direct the pulsing circuit to the rotary magnet.

the rotary movement of the shaft, relay A follows pulses of the second series and, when at normal, es the rotary magnet. Note that the rotary magnet is cut off, and will again operate if relay A restores.

Testing Called Line: (Operated; relays A, B, also N). If the called line is busy, wiper EC engages a nded bank contact, thereby returning ground via the lead to the test distributer.

e called line is free, the testman may test the called over the test leads. The EC lead provides means reby the testman may control the BCO of the called

Releasing: (Operated; relays A, B, also VON). When testman opens the line loop, relay A restores to n B. Relay B restores, (1) removes ground from the ad to mark this switch free, and (2) closes the circuit ne release magnet.

Recapitulation: The reader probably has noticed a e divergence in the methods employed to describe uit operation. And perhaps wonders why the writer not fix on the one best method (in his opinion). To do would defeat one purpose of this text. Strowger uits have been designed by somewhat less than one ired men, but circuit explanations have been written undreds of men throughout the years. The writer eavors to present as many typical circuits as can be crammed into the limited space available, the explanation in each case closely following that written when the circuit was released into production. Thus the reader will become familiar with the varied literature of the art.

There is no royal road to the reading of circuits. But if the student understands what the circuit is intended to accomplish, it matters little how the explanation is worded. Many years were spent in writing and rewriting Part A, so that the student would have a basis for his circuit reading.

413 Party Line Service: See previous discussion in Section 118.

414 Terminal Per Station Service: In the terminal per station plan, by definition the number of connector terminals exceeds the number of line terminals by an amount which depends on the proposed number of party line stations. Consequently, separate distributing frame terminations are required for cross-connecting facilities. A separate line IDF (associated with an MDF) affords the best arrangement. Although a combined MDF and line IDF offering modified line IDF facilities may be used.

Alleged advantages, peculiar to the terminal per station plan, are said to include: (1) Improved efficiency of out-side plant facilities, (2) Equalization of originating traffic loads, (3) Simplicity of intercepting scheme, and (4) Ease of making changes in class of service. For complete discussion see Telephone Engineer and Management (Babka) 4-48.

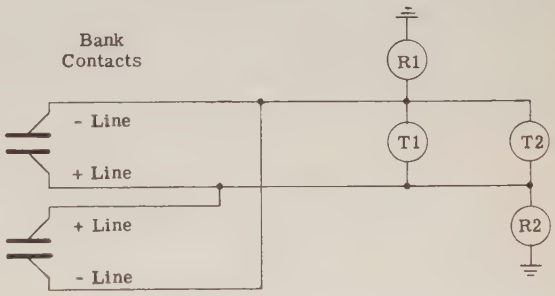



Fig. 3 - Divided Ringing.

414(a) Two-Party, Divided Ringing: Refer to Figure 3 and note that a two-party line has been established by connecting the ringer (R1) of station (T1) between the "-" side of the line and ground, and the ringer (R2) of the second station (T2) between the "+" side of the line and ground.

(A) Selection Made Within the Connector: This method of selection was rather fully discussed in Sections 218(a)(A) and 218(a)(B).

414(b) Five Party, Harmonic: This terminal per station scheme was discussed in Section 218(a)(C).

414(c) Two-Party, 1-Ring and 2-Ring: This simple code ringing scheme works on a terminal per station basis and was discussed in Section 218(d)(A).

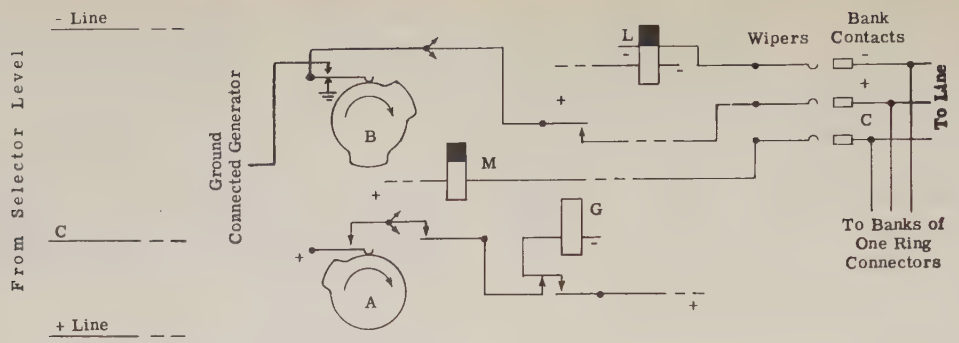



Fig. 1 - The Two-Ring Connector

The only novel feature in this connector is the provision of a "pick-up" lead to insure that the ringing will start at the beginning of the next code, and not in the middle of a code.

Refer to Figure 1 and assume that the "pick-up" cam A and the "two-ring" cam B are on a single shaft continuously rotating in a clockwise direction. This switch will respond to the "XX" digits in the usual manner and, upon completion of the rotary pulses, relay M will operate from resistance battery on the bank contact engaged by wiper C, and will prepare the circuit to relay G.

Relay G will energize at the next "pick-up" pulse, lock itself up and extend "two-ring" generator to the positive side of the called line. The ringing circuit is completed through the ringing relay L. Compare this circuit with that shown in Section 323, and do not confuse with the pick-up circuit discussed in Section 280(a). Pick-up circuits will be found in all code ringing connectors and in many specialty applications.

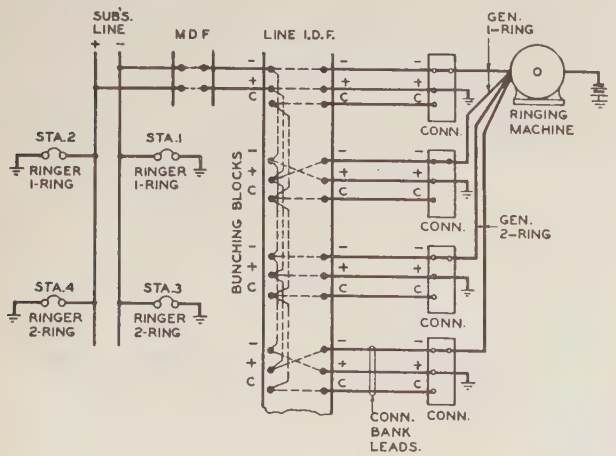



Fig. 2 - Semi-Selective Divided Ringing, Four Party Lines. (Repeated)

414(d) Four-Party, 1-Ring and 2-Ring: When the third and fourth parties are connected to a party line, all stations on the line are placed on a semi-selective divided ringing basis. The connection of the four stations is indicated in Figure 2.

415 Terminal Per Line Service: See previous discussion in Section 218(b).

CONTINUED FROM PAGE 76

Operating the "T Bat." key disconnects the VOM circuit from the testing circuit, and connects exchange battery and ground, through the windings of the supervisory relay, across the testing pair in order to supply transmission battery to the subscriber's set. The subscriber, installer, or trouble man is then able to converse with the testman.

In case the testman finds it necessary to retire from the circuit to perform other duties before the tests are completed, the "Prim. Talk" key is restored to normal. If the subscriber, installer, or trouble man hangs up, the supervisory lamp associated with the primary test cord will glow as an indication to the testman that the party has hung up.

(N) Transmission Tests: A transmission test feature is provided which enables the testman to make transmission tests on new subscriber station installations, and also in connection with the investigation of transmission complaints. This test embodies the following features:

(1) Provide means for reducing the transmission battery current to the line under test to a definite value which will be the same for tests on all loops, thus equalizing the battery supply on the different loops tested. This will produce a fairly uniform test condition and one which will permit the use of a definite loop condition as a basis of comparison.

(2) The employment of an artificial line to be connected in the circuit between the line under test and the testman's telephone set. A repeating coil separates the subscriber's line from the testing circuit. The transmission battery feed is through the 1-2 and 3-4 windings of the repeating coil. The artificial line is connected to the 5-6 and 7-8 windings of the repeating coil. The purpose of the artificial line is to increase the transmission equivalent of the testing circuit to approximately 30 miles of standard cable. This represents the transmission to be obtained on a typical toll connection. In addition, it is general experience that small differences in the volume of transmission can be more readily detected where the total transmission equivalent approximates 20 to 30 miles of standard cable.

CONTINUED IN COL. 2, NEXT PAGE

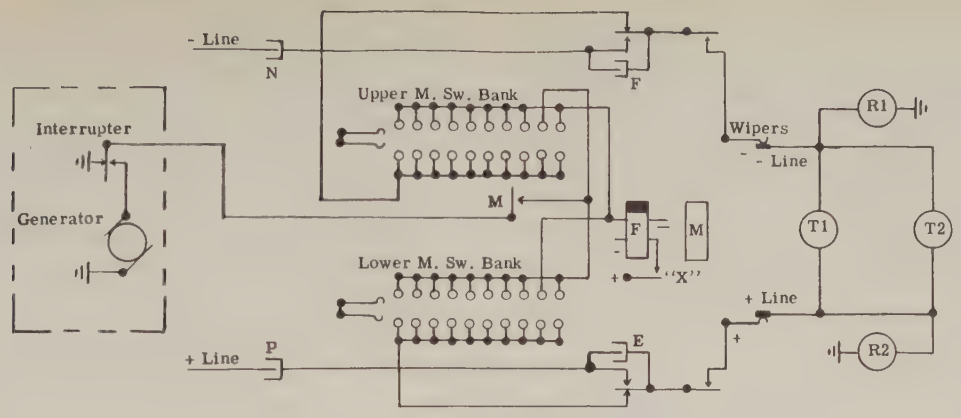



Fig. 3 - Two-Party Divided Ringing. Selection Made Within The Connector. Ground Connected Generator.

'a) Two-Party, Divided Ringing

Selection Made by Preceding Switch: A connector uit illustrating this feature was analyzed in Section 'a).

Selection Made Within the Connector: In this particu- connector, the first digit actuates a minor switch mechanics of the minor switch see Section 147). er now to Figure 3 and note that the two levels of a or switch are indicated. Relay F is the usual ring off relay, and relay M is the customary wiper closing y.

ne left of the figure will be found a ground connected ce of ringing current and its associated ringing rrupter. At the right of the figure is a two-party line. er R1, associated with telephone T1, is connected ween the "-" line and ground. While ringer R2, ciated with telephone T2, is connected between the line and ground.

e first digit dialed is "9" the connector will ring the "-" side of the line; while if any other digit had dialed on the minor switch, the connector would have over the "+" side of the line.

Ring-Back Tone: Generator current passes to the ng line by way of condensers E, F, N and P to give calling party ring-back indication. See Section 205(1) discussion of the various ring back schemes.

b) Frequency Selecting Connector: The two-hundred connector shown in Section 408(c)(B2) is actually a -frequency selecting connector. See also, Section b)(C).

CONTINUED FROM COL. 2, PRECEDING PAGE

(3) A talking test between the testman and the installer or trouble man at the subscriber's station. This means that in order that proper comparison may be made between the transmission obtained on one loop, and the transmission obtained on another loop, either on the same or different days, it is essential that the testers use care always to talk in the same manner and with their lips always in the same relative position with respect to the transmitter. This test should render it possible to easily discover defects which would cause any serious transmission losses.

For equalizing the battery supply to the different subscribers' stations, a variable resistance or rheostat is provided. By the rotation of the handle on the rheostat, resistance from 0 to 3000 ohms may be connected in the circuit. The rheostat is normally shunted out of the circuit by a turn key designated "Rheo.". The key is mounted on the VOM panel.

To make a transmission test, the testman operates the "T Bat." key, the "TMT" key and the "Rheo." turn key. Operating the "TMT" key connects the testman's telephone set to one end of the artificial line; the other end of the artificial line is connected to the repeating coil. The operating of the "TMT" key also connects the milliammeter circuit and the rheostat in series with the ring (negative) line. The testman then adjusts the rheostat until the needle of the VOM indicates that .040 amperes is flowing out over the subscriber's loop. This value, it is believed, should be generally satisfactory and corresponds to the battery supply on a 500 ohm loop. By building out the subscriber's loop in this manner, and by introducing the artificial line, the transmission takes place over a circuit representing approximately 30 miles of standard cable.

In order to provide a more accurate reading of the current flowing over the subscriber's loop, the "150 MA" key is operated, which switches the milliammeter circuit from the 0-600 scale to the 0-150 scale.

A "Bat. Cont." key is provided which, when operated, shunts out the two (2) 100 ohm resistances in series with the battery feed coil. This feature allows the testman to increase the battery feed to the subscriber whenever necessary.

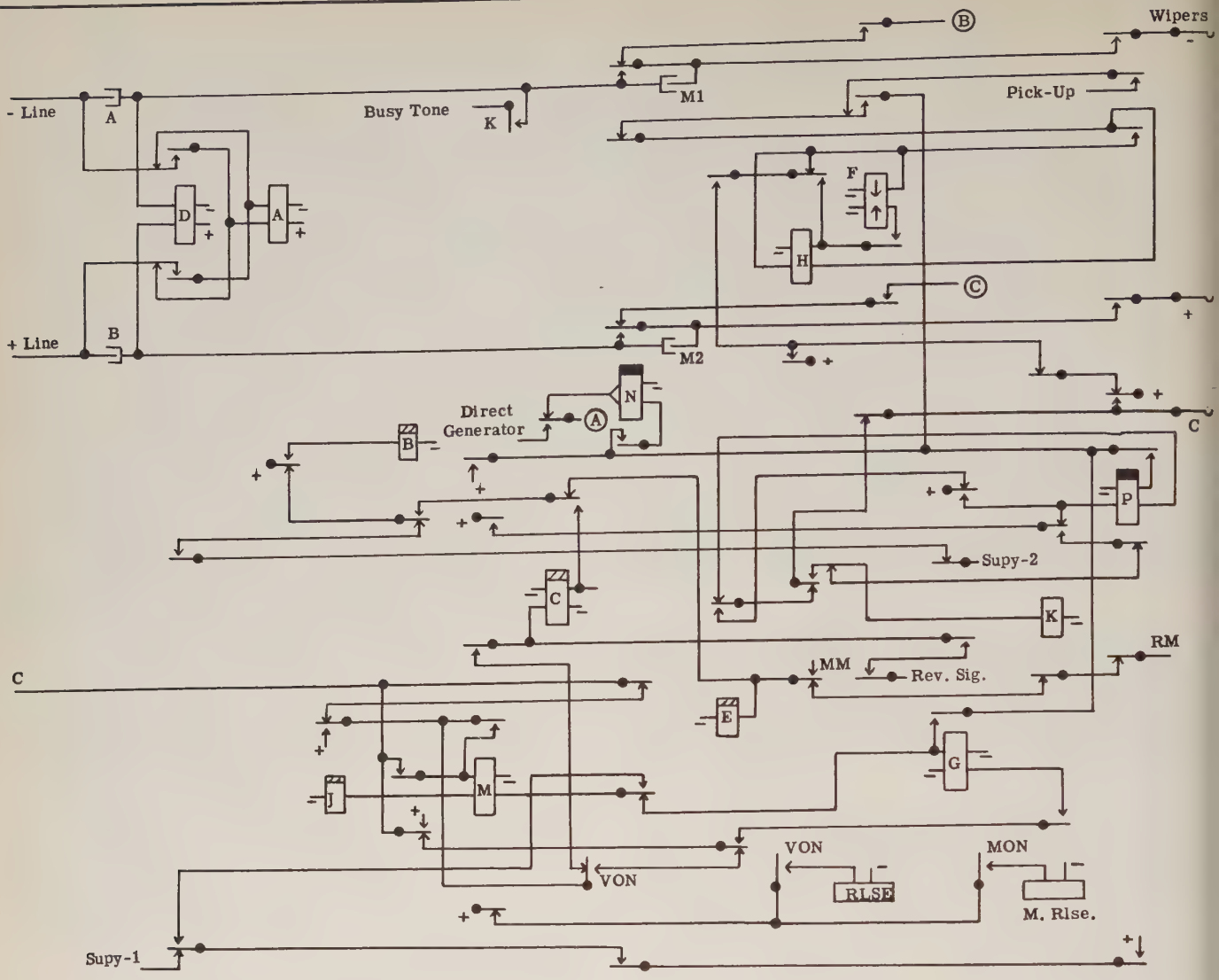



Fig. 1 - Code Ringing Connector. Reverting Call By Directory Number. (Call Outs Ⓐ, Ⓑ, & Ⓒ, Refer To Fig. 2).

415(c) Code Ringing, Ten-Party Selection: The connector circuit shown in Figure 1, is a 5-code circuit to be used with absence of ground selectors. The first and second digits dialed select the line. The third digit selects the ringing code. Code digits 1-5 ring on the negative side of the line, while code digits 6-0 ring on the positive side of the line.

If the dialed line is busy, the calling party will receive busy tone. When he restores his handset, the switch train will release in the customary manner. But if it is a reverting call (the subscriber has knowingly dialed his own line number, followed by the code digit of the desired party), this connector will not release when the called party restores his handset, but will remain operated to ring the called party, and the calling party as well.

(A) Seizure: This switch is marked free by the absence of ground on the C lead. When a connection is extended to this switch, line relay A operates and closes B. Relay B operates, grounds the C lead to hold preceding switches, and closes upper M. Relay M operates, closes lower C, and prepares a holding circuit for relays G, N and P.

(B) Vertical Motion: (Operated; relays A, B, M and C) Relay A follows the first series of impulses and, when a normal, closes upper C and the vertical magnet in parallel. The vertical magnet raises the shaft and wipers to the desired level. The VON springs operate on the first vertical step and open lower C. Relay C restores after the series and directs the impulsing circuit to relay E and the rotary magnet.

(C) Rotary Motion: (Operated; A, B, M, also VON) Relay A follows the second series of impulses and, when at normal, closes E and the rotary magnet in parallel. Relay E operates on the first pulse and closes upper F. Relay F operates to prepare the circuit of lower H. The rotary magnet follows the impulses and advances the wipers to the called line. Relay E restores after the series to remove ground from upper F. Relay F remains energized through lower H to ground at springs of M. Relay H operates in series with upper F and directs the impulsing circuit to the motor magnet of the minor switch.

(D) Selecting the Ringing Code: (Operated; relays A, B, M, F, H, also VON). Relay A follows the impulses of the

d series and, when at normal, closes E and the minor ch motor magnet (MM) in parallel. Relay E operates ck upper H, and closes the lower (knock-down) ling of F. Relay F immediately restores, since its lings are differentially connected - a neat circuit ... The motor magnet of the minor switch follows the ulses of the series and advances its wipers accord-y. The motor switch off-normal springs (MON) ate on the first step and prepares the circuit of the or switch release magnet. If the called line is busy, circuit to K is closed from ground on the C wiper, Sub-section (I). Relay C restores after the series opens upper H. Relay H restores and extends the iper, through lower P, to ground at springs of relay M.

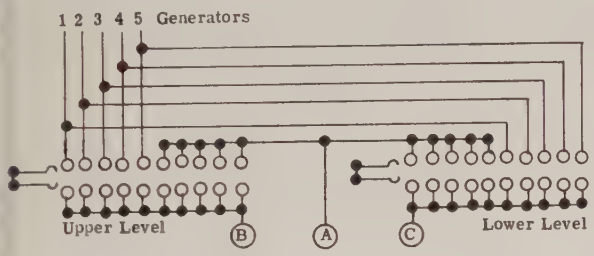



Fig. 2 - Code Selection Via Minor Switch.

Seizing the Called Line: (Operated; relays A, B, also VON and MON). If the dialed line is idle, resist-e battery (BCO of the called line) on the C wiper ses P. Relay P operates, locks its upper winding, es direct ground on the C wiper, and closes the ck-up" lead through lower H to upper F. Relay F n operated, will extend coded ground connected erator as determined by the wipers of the minor tch, see Figure 2. Generator is placed on the "-" er if the code digit was 1 to 5, or on the "+" wiper if code digit was 6 to 0. Note that the upper winding of g cut-off relay N is extended to the side of the line osite that on which generator is being impressed.

Ringing the Called Station: (Operated; relays A, B, P, also VON and MON). At the beginning of each code le, the "pick-up" lead is momentarily grounded to se upper F. Relay F operates on the next pick-up se, locks its upper winding to ground at springs of ay M, and extends generator and relay N as above scribed. A part of the coded generator passes to the e by way of condensers M1 and M2 to give the calling scriber ring-back indication.

Called Party Answers: (Operated; relays A, B, M, F, also VON and MON). When the called party swers, a direct current path is closed from upper N to nerator ground. Relay N operates, locks its two ndings in series, opens F, and extends back bridge ay D to the called line. Relay D operates, reverses tery on the calling line, removes ground from the y-1 lead, and closes J in series with lower M. Relay J rates and closes a holding circuit to upper M. Trans-ssion battery is supplied the calling and called parties rough A and D respectively.

) Releasing: (Operated; relays A, B, M, P, N, D, J, so VON and MON).

(H1) Calling Party First: The loop to A is opened when the calling party disconnects. Relay A restores to open B and close E. Relay B restores, removes ground from the C lead to release preceding switches, grounds Supy-2 lead to indicate that the called party is still on the line, and opens E. Relay E restores to re-ground the C lead to make this switch busy.

When the called party restores his handset, the loop to D is opened. Relay D restores and opens slow to release J. Relay J restores to open upper M. Relay M restores, opens N and P, and closes both release magnets.

(H2) Called Party First: The loop to D is opened when the called party restores his handset. Relay D restores, returns normal polarity to the calling line, grounds Supy-1 to give an indication that the calling party is holding the connection, and opens J. Relay J restores, but without effect.

When the calling party disconnects, the loop is opened to A. Relay A restores and opens B. Relay B restores and opens M. Relay M restores, removes ground from the C lead to release preceding switches, opens N and P, and closes the release circuits.

(I) Called Line Busy: (Operated; relays A, B, M, E, H, also VON and MON). When the called line is busy, wiper C engages a grounded bank contact and, before H restores, a circuit is closed to K. Relay K operates, prepares its locking circuit, opens the rotary magnet circuit to prevent further rotation, and connects busy tone to the calling line. Relay E restores, relay H restores and completes the locking circuit to K. The calling subscriber will restore his handset upon hearing busy tone, and the release of the switch train follows in the usual manner.

(J) Reverting Call By Directory Number: (Operated; relays A, B, M, K, also VON and MON). Assume the connection has been extended as described above in Sub-sections (A), (B), (C), and (D). As this is a reverting call (calling party dials the line number of his own line), busy tone will be received as described in Sub-section (I).

The calling subscriber restores his handset when he hears the busy tone, thus opening the calling loop. Relay A restores, opens B and closes E. Relay E operates to place ground on the C wiper. Relay B restores, removes ground from the C lead, and opens slow to release relay E. The ground extended to the C wiper by relay E returns over the C lead to hold upper M and close lower G. Relay G operates, locks its upper winding, closes a holding circuit through lower M to J, and removes ground from the C wiper to release the preceding switches of the train. Slow to release relay E now restores, re-grounds the C lead to make this switch busy, and extends lower P to the C wiper. Relay P operates from battery through the BCO of the called line, closes the pick-up lead to F, closes the line circuit through to the wipers, and opens K.

Ringing is the same as described above in Sub-section (F), with the exception of "Revertive Signal". Relay F operates and, among other things, extends the revertive

signal lead to lower C. Relay C responds to intermittent ground pulses on the revertive signal lead and closes direct generator to the side of the line opposite to that on which the code is being impressed. The revertive signal will actuate the ringer at the calling station, should it be on the side opposite to that of the called station. Figure 1 indicates the circuit arrangement at this time.

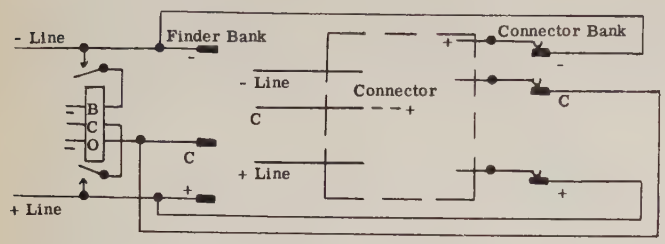



Fig. 1 - Reverting Call By Directory Number.

(J1) Called Party Answers: (Operated; relays M, G, J, P, F, C intermittently, also VON and MON). When the called party answers, the ring is cut off as described above in Sub-section (G). The cessation of the ring at the calling station is an indication that the called party has answered. The calling party then removes his handset and the conversation takes place. Note that relay N transfers the holding circuit of J and M to springs on D. Transmission battery is supplied to both subscribers from relay D.

(J2) Releasing: (Operated; relays M, G, J, P, N, D, also VON and MON). When both parties restore their handsets, the loop to D is opened. Relay D restores to open J which, in turn, opens M. Relay M restores, opens G, N, and P, and closes the circuit to both release magnets.

(K) Recapitulation: See general discussion in Section 218(d)(D), also note that the two-hundred line connector discussed in Section 408(c)(B2) is a ten-party code ringing connector.

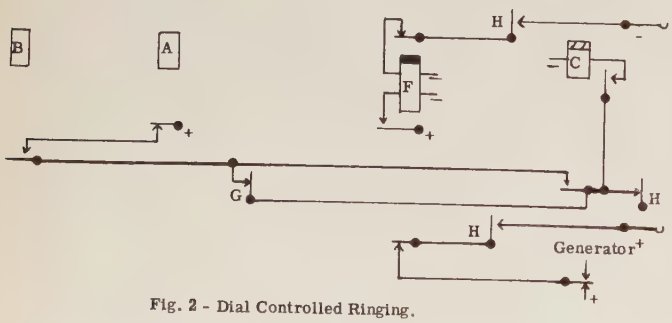



Fig. 2 - Dial Controlled Ringing.

415(d) Code Ringing, Dial Controlled: The circuit shown in Figure 2 is essentially that of the ten-line connector analyzed in Section 408(a)(A). A slight change has been made to afford dial controlled ringing.

(A) Ringing the Called Party: (Operated; relays A, B, D, and H). The ringing is now controlled by the impulses of the dial. Dialing "0" produces a long ring, and dialing "3" a short ring.

Relay A follows the dial pulses and, upon restoring, closes C. Relay C operates to connect non-interrupted grounded generator to the "+" side of the called line. The circuit is completed through the ringers bridged across the called line, the upper winding of ring cut-off relay F, and thence to battery.

Relay C restores after the series and connects the "+" wiper to ground. See also, Section 135.

415(e) Code Ringing, Push Button Control: The connector circuit shown in Figure 3 has several unique features; (1) push button ringing, (2) repeating coil to separate the calling and called lines, (3) over-ride of busy, and (4) no ring cut-off.

(A) Individual Connector: This connector is not a part of a switch train, but is an individual connector operating directly from a dial telephone equipped for push button ringing.

(B) Seizure: Relay A operates over the line loop and closes B. Relay B operates, closes upper C through the VON springs and places ground on the C wiper. Relay C operates, (1) prepares a circuit to the vertical magnet in parallel with its own lower winding, and (2) closes the lower winding of G in series with the upper winding of E. Relays E and G operate and lock themselves to ground at relay A.

(C) Vertical Stepping: (Operated, relays A, B, E, and G). Relay A follows the first series of dial pulses. At each restoration, a circuit is closed through lower C and the vertical magnet. At the end of the series, relay C restores and directs the pulsing circuit to relay E and the rotary magnet.

(D) Rotary Stepping: (Operated; relays A, B, E, G, also VON). Relay A follows the second series of dial pulses to operate the rotary magnet and maintains E energized. Note that the first restoration of A opened the lower winding of G, whereupon G restored to open upper E. Relay E restores at the end of the series to prevent further rotation.

(E) Over-Ride of Busy: No busy test is provided as the wipers connect with the called line whether it is in use or not.

(F) Seizing the Called Line: (Operated; relays A, B, E, also VON). Relay E, restoring at the end of the second series of dial pulses, closes H. Relay H, slow to operate because of its short circuited lower winding, now energizes and extends various circuits to the switch wipers.

If the called line is a "tie line" to a manual switchboard, there will be ground on the associated EC bank contact. Relay F operates from this ground, (1) locks up to VON, and (2) bridges an inductive loop (relay K) across the "-" and "+" wipers to operate the common battery line equipment of the tie line.

(G) Ringing the Called Party: (Operated; relays A, B, H, also VON). To ring the called line, with any desired code, the push button at the calling telephone is operated to ground both sides of the line. Relay A remains operated. The differential relay D will be unbalanced,

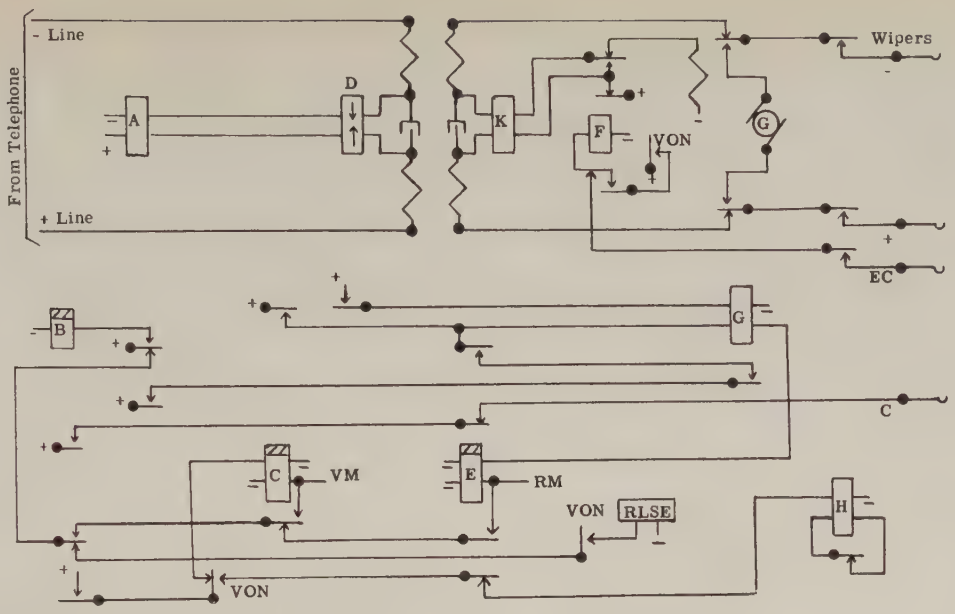



Fig. 3 - Individual Connector, Push Button Ring, Over-Ride Of Busy.

will operate to close G. Relay G will operate to nd ringing current to the called line. Note there is no ; cut-off. The called party will just have to take it - ne ear.

Transmission: When the called party answers, he is talking battery through the two windings of back dge relay K.

Release: When the line loop is opened, relay A tores to open B. Relay B restores to close the release net circuit.

Reverting Calls: A general discussion of this oject will be found in Section 218(c).

Reverting Calls By Special Number: The illustrative rcuits presented in this and following sub-sections have en selected because they introduce certain novel and eresting circuit devices. In many instances the details operation will not conform exactly with that outlined the corresponding sections of Part A.

Care should be exercised to distinguish between, (1) general rules, and (2) exceptions. As an illustration, the general rule is that "further rotation" of the connector switch is impossible after a directory number has been dialed. But by way of exception, we find the special case of the test connector. Broadly speaking, the general rules are set forth in Part A, while Part D illustrates many of the exceptions - and the exceptions to the exceptions.

417(a) Reverting Call, 2-Party, Divided Ringing: The reverting call equipment shown in Figure 4 is quite simple because there need be no digits "dialed into" this equipment. Since there are but two parties on any line, the "other party" may be signalled by merely dialing the special code (usually three digits, see Section 157) assigned to reverting call service. When there are more than two parties on a line, the reverting call code is dialed to extend the connection to the reverting call equipment, after which additional digits must be "dialed into" this equipment to select the desired party on the line.

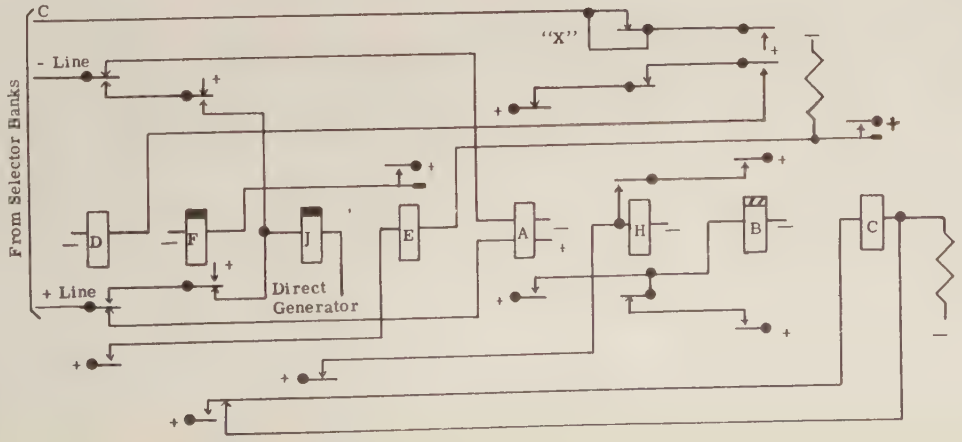



Fig. 4 - Reverting Call, Divided Ringing.

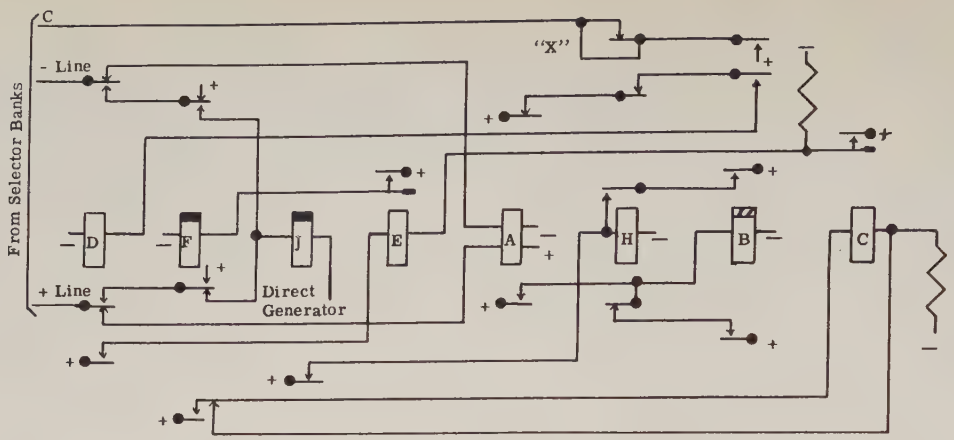



Fig. 1 - Reverting Call, Divided Ringing. (Repeated)

Refer to Figure 1 and note that relays E and C are "weighted spring" relays, previously discussed in Section 318(a).

(A) Seizure: This switch is marked free in the banks of preceding switches by resistance battery on the C lead. When the line loop is closed, relay A operates to close B. Relay B operates, (1) places ground on the release trunk C to hold preceding switches, and (2) locks up independent of springs on relay A.

(B) Calling Party Replaces Receiver: (Operated; relays A and B). Relay A restores when the line loop is opened, (1) opens the starting circuit to B, and (2) closes D. Relay D operates, (1) connects battery connected direct generator through relay J to "+" line, and (2) closes E through a limiting resistance.

Relay E operates to close an intermittent circuit to slow to operate F. Relay F operates in due time, (1) transfers generator from "+" line to "-" line, and (2) closes C. Relay C operates to close an intermittent circuit that shunts E. Relay E restores in due time and opens F. Relay F restores, (1) transfers generator from "-" to "+" line, and (2) opens and short circuits C. Relay C, slow to release because of the short circuit, eventually restores and removes the short circuit from E. Relay E again operates, and the cycle keeps repeating until a receiver is removed on the calling line.

(C) Ringing Called and Calling Stations: (Operated; relays B and D, also E, F, and C intermittently). The battery connected generator is alternately applied to each side of the line, the circuit is completed to ground through the condenser and ringer at the calling and called stations.

(D) Receiver Removed: When the receiver at either station is removed, relay J energizes on the resulting direct current flow. Relay J operates to close H. Relay H operates, (1) locks itself to make springs on B, (2) opens the locking circuit of B, and (3) opens D.

Relay D restores, (1) again bridges A across the line, and (2) opens J and E. Relay A operates to reclose B before that slow to release relay has had time to fall away. Relays C, E and F restore. Transmission battery is fed both parties from relay A.

(E) Both Receivers Replaced: (Operated; relays A, B and H). The circuit to A is opened when the last party restores his receiver. Relay A restores to open B. Relay B restores to remove ground from the release trunk, and to open H. Relay H restores, and the circuit is ready for the next call. If the called station does not answer, the calling station must remove and replace his receiver to release the connection.

(F) Release of Reverting Call Trunk: From the description just given it is obvious that the reverting call trunk will be held during the time of conversation. The traffic may therefore necessitate a plurality of reverting call trunks.

Note the strap "X" which shunts a pair of break springs on relay H. If this strap is eliminated, the entire switch train will release upon the operation of relay H. In which event, the BCO of the calling line would restore and, since the line loop is still closed, the associated line relay would function to extend the connection to an idle first selector. The two parties would then draw talking battery from the line relay of the first selector but, (1) they would be inconvenienced by hearing dial tone, and (2) the "permanent" signal would come in if the first selector was not moved off normal within a certain length of time.

(G) Line Lock-Out: Talking battery as described above would be decidedly unsatisfactory. So, if you want to economize on reverting call equipment it will be necessary to provide "line lock-out" equipment for each party line in the exchange, see Section 401(f).

The line lock-out equipment will function when ground is removed from the C lead irrespective of the cause, be it (1) "timing out" equipment, or (2) reverting call equipment.

417(b) Reverting Call, 10-Party, Divided Ringing: The general construction of a reverting call switch is much the same for all types of party-line use. Mechanically, a reverting call switch consists merely of a group of relays and two minor switches. The minor switches are

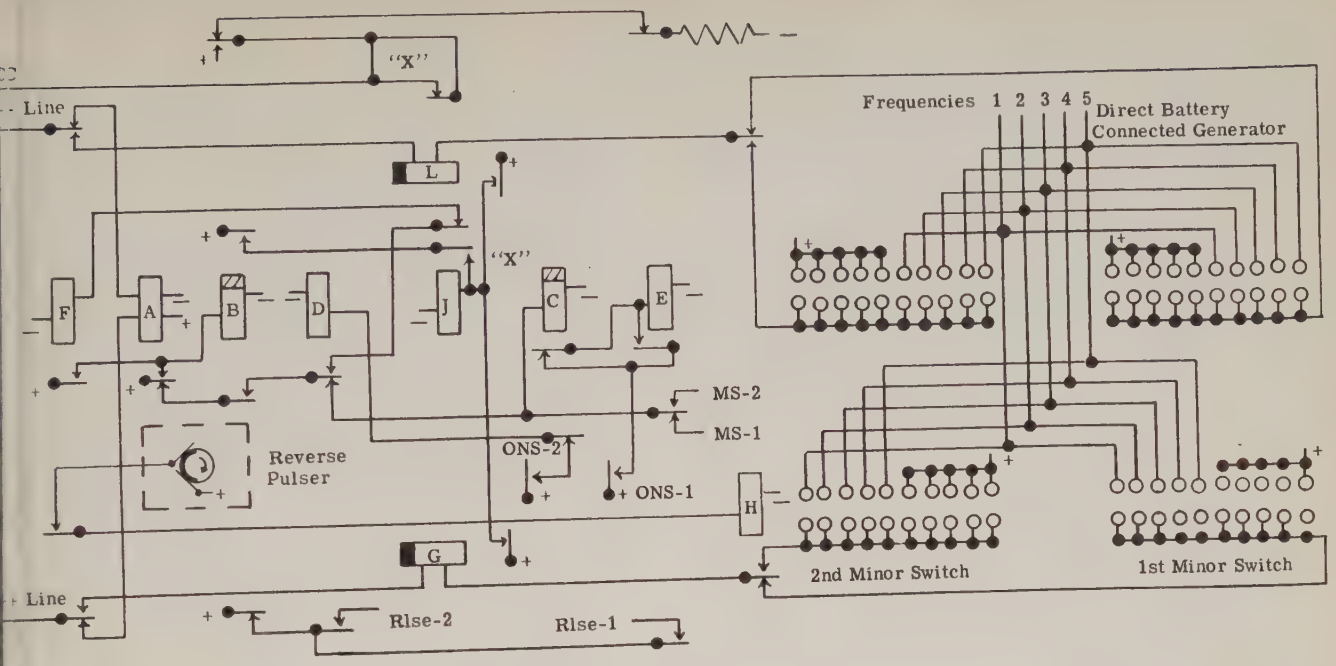



Fig. 2 - Reverting Call, 10-Party, Divided Ringing.

zzed to select the proper frequencies as codes of the ing current to be applied to the line and also to ct the side of the line. It must be apparent, however, certain differences in circuits are necessary for ches to be operated on such diverse types of systems armonic ringing and code ringing. A switch intended a maximum of ten stations per line which are rung on rmonic frequency basis will be discussed in this tion.

there are more than two parties on a line, the re- ing call code must consist of two parts. The first t (usually three digits) extends the call from first ctor to special second selector and thence to special d selector. The second part consists of two digits, the last digit of the calling party's directory number, (2) the last digit of the called party's number. These digits select the proper ringing frequencies.

code may be furnished by an information operator, a card furnished each party line subscriber, or by ormation contained in the directory, depending upon system involved and the local operating company's ference.

the right of Figure 2 will be found two minor switches, h having two levels of bank contacts. No wipers are own, but it is to be understood that a bridging wiper vances from left to right across each level.

Seizure: This switch is marked free in the selector nks by resistance battery on the C lead. Relay A erates from the line loop and closes B. Relay B erates, grounds the C lead to hold preceding switches, d prepares the circuit to C and MS-1 (rotary magnet the first minor switch) in parallel.

) Selecting First Frequency: (Operated; relays A and . Relay A follows the pulses of the first series and, each de-energization, closes C and MS-1. Relay C operates, and remains operated throughout the series. Rotary magnet MS-1 operates on each pulse to advance the associated bridging wipers across the bank. Off normal springs ONS-1 operate on the first step and prepare a circuit to relay E. Relay C restores at the end of the first series and closes E. Relay E locks up independent of springs on relay C.

(C) Selecting Second Frequency: (Operated; relays A, B, E, also ONS-1). Relay A follows the pulses of the second series and, at each de-energization, closes C and MS-2. Relay C operates, and remains operated throughout the series. Rotary magnet MS-2 operates on each pulse to advance the associated bridging wipers across the bank. Off normal springs ONS-2 operate on the first step and prepare a circuit to relay D. Note that the term "bridging wiper" here means a wiper which bridges the upper and lower bank contacts at each step, it is not the bridging wiper discussed in Section 301(a). Relay C restores at the end of the second series and closes D. Note that E remains operated. Relay D operates to prevent further rotation and prepares the circuit of relay F.

(D) Calling Party Replaces Receiver: (Operated; relays A, B, E, D, also ONS-1 and ONS-2). When the handset at the dialing station is replaced, the circuit to A is opened. Relay A restores, closes F and opens B. Relay F operates, (1) extends "+" line, via G, to the lower level of the first minor switch, (2) extends "-" line via L to the upper level of the first minor switch, (3) recloses B, and (4) closes H to "reverse pulser". The reverse pulser (not a part of the reverting call switch), may be a cam or other device which will deliver pulses of proper ratio and speed.

(E) Ringing: (Operated; relays A, B, E, D, F intermittently, also ONS-1 and ONS-2). The ringing scheme may now be briefly outlined. Five different frequencies are used, and there may be as many as ten parties on one line. The five frequencies used are connected to the reverting

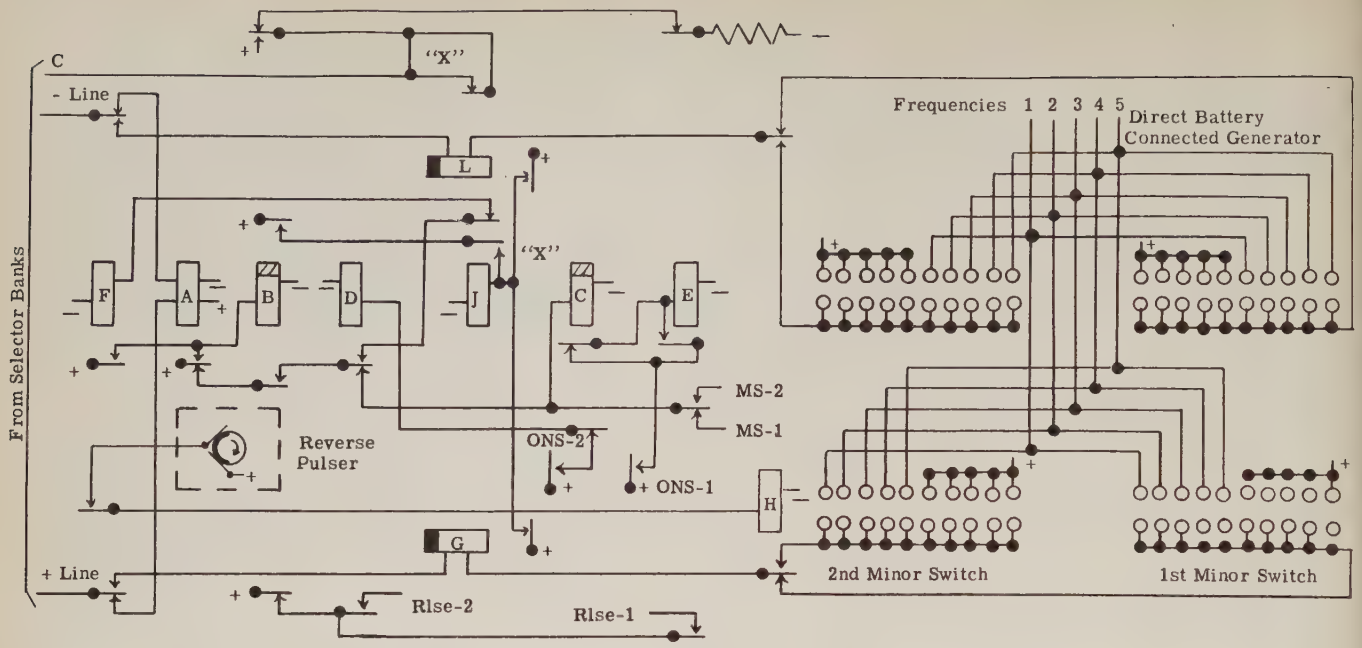



Fig. 1 - Reverting Call, 10-Party, Divided Ringing. (Repeated)

call switch as direct (uninterrupted), battery connected generator. The five parties whose ringers are connected between the negative side of the line and ground are assigned digits 1 to 5 corresponding to the frequencies 1 to 5 respectively. The five parties whose ringers are connected between the positive side of the line and ground are assigned digits 6 to 0 corresponding to frequencies 1 to 5 respectively. The two digits dialed on this switch by the calling party are the frequency selecting digits of the calling and called parties, dialed in the order named. Each ringer will respond only when its particular frequency is sent over the side of the line to which it is connected. If the ringers of the calling and called parties are connected to the same side of the line, this switch will send out the two frequencies alternately on the correct side of the line. If the ringers of the calling and called parties are connected to opposite sides of the line, this switch will send out the two frequencies alternately on the respective sides of the line.

This is accomplished by the intermittent operation of relay H. When relay H is restored, the frequency corresponding to the first digit dialed (that which operated the first minor switch) is sent out over the proper side of the line. If the digit dialed is from 1 to 5, generator will go out over "+" line via G, and ground will be placed on "-" line via L. If the digit dialed is from 6 to 0, generator will go out over "-" line via L and ground will be placed on "+" line via G. When H is operated, the frequency corresponding to the second digit dialed (that which operated the second minor switch) is connected to the proper side of the line. Slow to operate relays L and G will not operate on ringing current. Under each condition of ringing, ground is connected to the side of the line opposite that over which the ringing current is being sent. Thus a direct current operating circuit is prepared such that when any telephone handset on the line is lifted, direct current flows through either G or L.

(F) Receiver Removed: When a receiver is removed, either G or L operates to close J. Relay J operates, locks up and opens F. Relay F restores, (1) opens L (or G), (2) opens H, opens B, and (3) closes the line through to relay A. Relay A operates from the line loop and recloses B. Transmission battery is supplied by relay A.

(G) Both Receivers Replaced: (Operated; relays B, E, D, J, A, also ONS-1 and ONS-2). When both the calling and called parties replace their handsets, the circuit to A is opened. Relay A restores and opens B. Relay B restores, (1) removes ground from the C lead to release preceding switches, (2) opens J, and (3) closes both release magnet circuits. Both minor switches return to normal, relays D and E are opened at their associated off normal springs. Relays D and E restore to open both release magnets.

(H) Line Lock-Out: If the parties are to receive talking battery from their own line equipment, see Section 401(f), thus freeing the reverting call equipment, the strap "X" on springs of relay J will be eliminated. Relay J, operating when a receiver is removed to answer the call, will now remove ground from the C lead to release the switch train.

EDITORIAL NOTE: Just as nature abhors a vacuum, so does a publisher regard white space that isn't working. The format used in this book -- the illustration under discussion is always in view -- results in considerable white space.

This white space is now going to be put to work and, with Dr. Smith's kind permission, we proudly present his "Christus Victor". The two philosophys of life -- "Christus Victor" and "Caveat Emptor" (Caveat Emptor was crowded out of this edition -- look up a Fifth Edition in your public library) -- are worthy of thoughtful reading and careful comparison, as they represent the dia-

ttrically opposed views of two men who have grown together in the telephone business.

·· over on the right is the good Doctor confessing faith and serene in the belief that "the universe is olding as it should". Equally far to the left is the conformist Hershey disclaiming any fear of God, n or the devil and insisting upon "the necessity of arly separating theory from fact". Probably both wrong, and a middle course is to be preferred.

eology and philosophy have no place in an engineer- text book, as has been pointed out to us by several ans of Engineering. But we are not writing for the ans, and it is our sincere belief that the student en- eer will profit greatly by a thoughtful reading of h "Christus Victor" and "Caveat Emptor".

## CHRISTUS VICTOR

By Arthur Bessey Smith

rly Training: The Bible is true at face value. My rents lived consistent lives, just the same every day they professed on Sunday.

e most essential basic Bible truths are as follows: . God created the world and universe and all con- nts (Gen. 1:1). ¶2. God made man pure in character en. 1:27). ¶3. Man sinned, incurring guilt and a na- re prone to sin (Rom. 6:22, Jere. 17:19). ¶4. God nt into the world his only begotten son, the Lord sus Christ (Gal. 4:4-5), to live as God and man, but thout sin (1 Peter 2:2). ¶5. He died for our sins, to ake atonement (1 Cor. 15:3, 1 Peter 2:4). ¶6. Every rson who believes in God's record and accepts the ord Jesus Christ as his Savior will receive forgive- ss of sins, the guilt removed (Acts 10:43), and will changed in nature (John 3:1-16). ¶7. It is the duty the born-again believer to dedicate himself com- etely to the Lord Jesus Christ (Rom. 12:1-3).

believed my parents, completely accepted the teach- gs of the Bible, asked God for the sake of Jesus to rgive my sins, He did, and I found joy in His service.

o Stand Alone: Part of the early training was the ility to stand alone, for born-again Christians are a mall fraction of all people.

jectives In Life: Daily fellowship with the Lord sus Christ and complete reliance on Him for guid- ce, and eventually a life through all eternity in His esence - a long time plan.

he mutual love and confidence of a lovely Christian oman, with home and children according to God's ws.

njoyment of useful work, well done, with such finan- ial return as it brings.

CONTINUED IN COL. 2, PAGE 175

418 Reverting Call By Prefix To Directory Number: The circuit about to be discussed is quite unusual and warrants study principally because of certain interesting circuit devices. It will function only in a network using five digit numbers, where the second digit determines the service, and the fifth digit determines the ringing code. The service given may be 20-party bridging or 10-party divided ringing.

418(a) Digit Absorption: This reverting call switch is reached by dialing a single digit prefix. The calling party then dials the five digit directory number of the called station (another station on the same line). As this switch is interested only in the ringing digits of the called number, it must "absorb" the first, third and fourth digits.

Only one two level minor switch is employed. This switch responds to a certain digit, then "drops back", and is again advanced by a later digit. Another interesting feature is that one of the minor switch wipers closes a relay circuit "on the run". That is, if the minor switch is dialed 7, 8, 9, or 0, a relay circuit is closed as the wiper passes over bank contact number six.

418(b) Conversation Timing: This switch is not held up during conversation but, for the sake of our index, this sub-section has been so headed. What actually happens is that the connection is "timed out" in case of incomplete dialing or an unanswered call. The timing circuits shown here are similar to those used to "time out" a connector held up too long, or a selector held by a permanent.

418(c) Code Ringing: The ringing scheme here employed provides 20 different codes, ten in the first group and ten in the second group. The minor switch on its first response selects the code group, and on its second response selects one of ten code leads. Equipment, exterior to this reverting call switch, causes the code leads to become associated with the previously selected code group.

The code leads extend ground pulses, properly spaced and of required length. Associated with each group is a "pick-up" lead which will extend a single ground pulse just before the start of the associated code cycle. The pick-up pulse actuates a relay (G) which locks up to a "holding ground" lead, ground is removed from this conductor when the code cycle is completed. The above relay, when locked up, extends the selected code conductor to a relay (K) which operates on each ground pulse and applies direct battery connected generator to the line.

Direct generator may be applied, (1) to the negative side of the line, or (2) to the positive side of the line. The side of the line upon which generator is to be impressed is determined by the first operation of the minor switch. In the opening paragraph we used the words, "where the second digit determines the service". The "service" comprises two elements, (1) the code group to be used, and (2) the side of the line upon which generator is to be impressed to ring the bell at the called station.

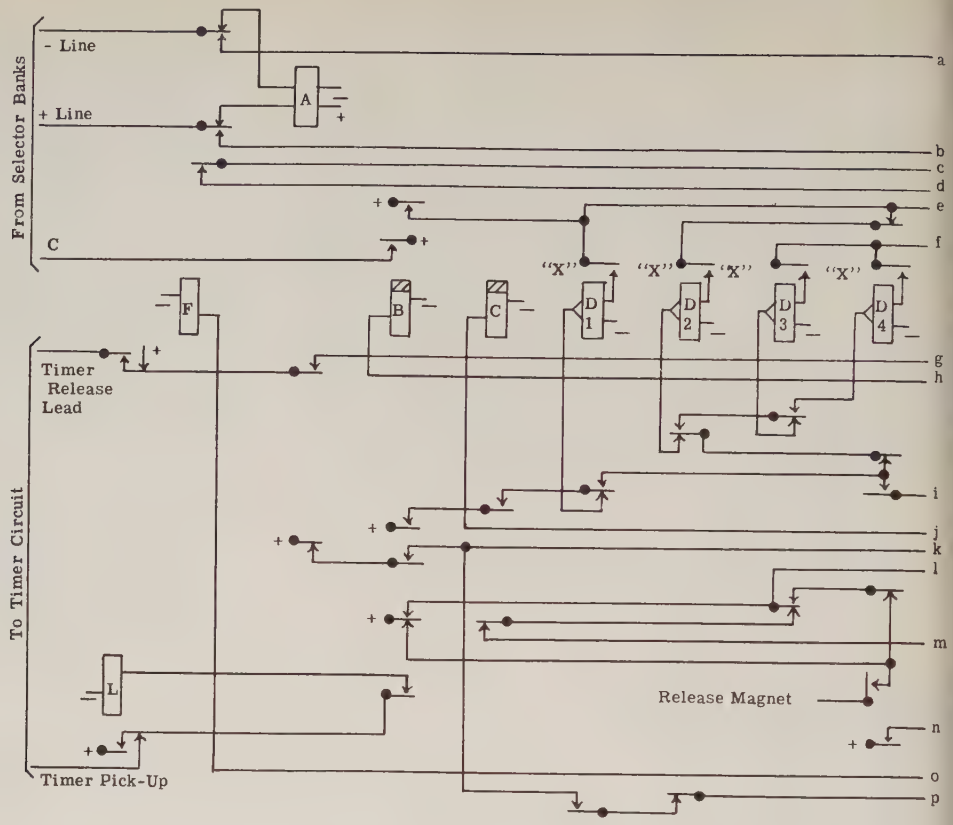



Fig. 1 - Reverting Call, 20-Party, Code Ringing.

418(d) Detailed Circuit Operation: Refer now to Figure 1 which shows reverting call equipment to serve 20-party bridging or 10-party divided.

(A) Seizure: This circuit is marked free in the banks of preceding switches by the absence of ground on the C lead. The closure of the line loop causes A to energize and close release relay B.

Relay B operates, (1) prepares a locking circuit for the "D" relays, (2) returns ground on release trunk C, (3) prepares an operating circuit for the "D" relays, (4) prepares a pulsing circuit to C and, on certain digits, also to the rotary magnet of the minor switch, (5) prepares a locking circuit for the "H" relays, (6) prepares a release circuit, and (7) starts "conversation timing".

No slow acting release relay could possibly carry the spring pile-up shown here. In actual practice the "B" relay would probably mount a single pair of make springs to operate a "slave relay". The latter relay doing the actual work. As a further simplification, we have assumed that all associated equipment is in continious operation. In practice additional springs are mounted here and there to, (1) start the ringing machine, and (2) start the timing device, etc.

(B) First Digit Dialed: (Operated; relays A and B). Relay A, following the pulses of the first series, opens B and closes C. Slow to release relay B remains operated. Slow to release relay C energizes on the first pulse and remains operated throughout the series. Relay C operates to close two-step relay D1 (see Section 311). Relay D operates to close only its "X" contacts. At the end of the series, slow to release relay C restores and removes operating ground from D1. Relay D1 operates fully, extends the counting chain, and prepares the rotary magnet circuit. The first digit performed no function except the operation of D1, and so is said to have been "absorbed".

(C) Second Digit Dialed: (Operated; relays A, B, and D1). Relay A, following the pulses of the second series, opens B and closes C in multiple with the rotary magnet. Relay C operates to close two-step relay D2. Relay D2 operates to close only its "X" contacts. The rotary magnet advances the wipers one step for each pulse of the second digit. The off-normal springs ONS close at the first step. Relay C restores at the end of the series to remove operating ground from D2, and to extend ground to contacts 4 and 5 of the upper bank. Relay D2 operates fully, extends the counting chain, and opens the rotary magnet circuit to prevent further rotation.

The wipers of the minor switch are now standing on contacts corresponding to the second digit dialed. The lower wiper is ineffective in any position because of open contacts on relay G.

If the digit 4 had been dialed, the upper wiper would have extended ground (when C restored) to lower H2. In which case relay H2 would have operated to lock its upper winding and open an incomplete circuit to H4.

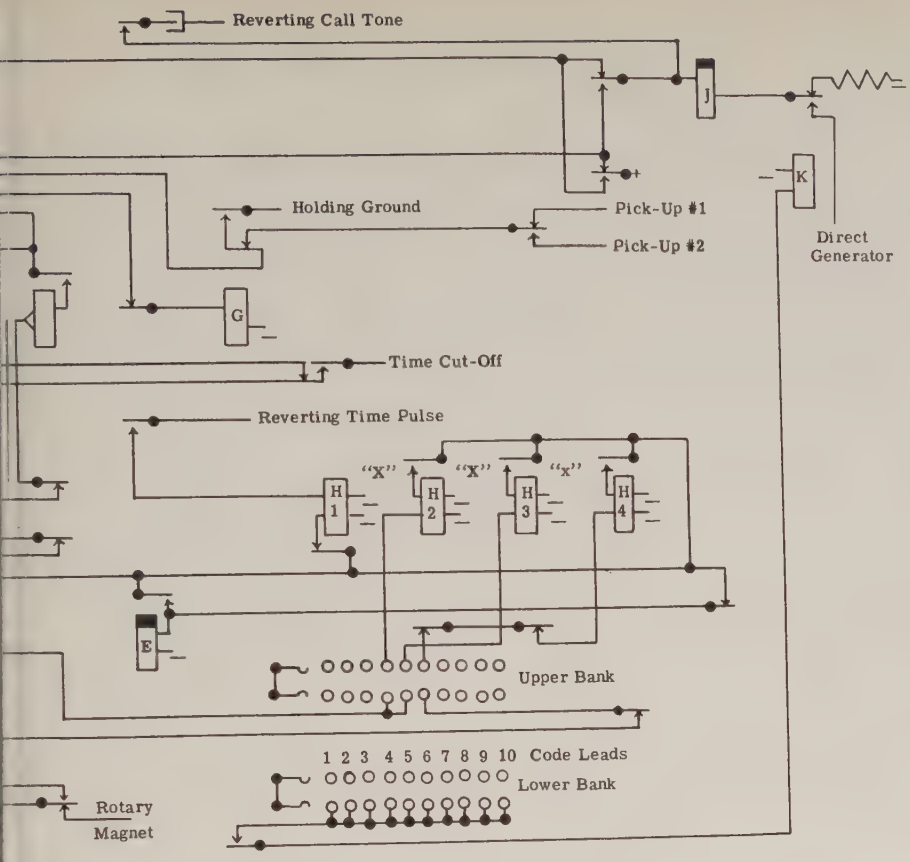



Fig. 2 - Reverting Call, 20-Party, Code Ringing.

the digit 5 had been dialed, the upper wiper would ave extended ground (when C restored) to lower H3. . which case relay H3 would have operated to lock its oper winding and transfer the circuit to relay G from e "pick-up #1" lead to the "pick-up #2" lead.

D) Third Digit Dialed: (Operated; relays A, B, D1, D2, nd possibly H2, or H3, also ONS). Relay A, following e pulses of the third series, opens B and closes C. elay C operates to close two-step relay D3. Relay D3 perates to close only its "X" contacts. Relay C estores at the end of the series to remove operating round from D3. Relay D3 operates fully, extends the ounting chain, removes ground from contacts 4 and 5 f the upper bank, and closes the release magnet of the inor switch. The release magnet operates to restore ne wipers to normal, thus opening the off-normal prings.

E) Fourth Digit Dialed: (Operated; relays A, B, D1, 2, D3, and possibly H2, or H3). Relay A, following e pulses of the fourth series, opens B and closes C. elay C operates to close two-step relay D4. Relay D4 perates to close only its "X" contacts. Relay C estores at the end of the series to remove operating round from D4. Relay D4 operates fully, opens the ocking circuit of D2, opens the operating circuit to D2, 3, and D4, extends the counting chain, and opens an ncomplete circuit to the release magnet. Relay D2 estores to prepare the rotary magnet circuit.

F) Fifth Digit Dialed: (Operated; relays A, B, D1, 3, D4, and possibly H2, or H3). Relay A, following the pulses of the fifth series, opens B and closes C in multiple with the rotary magnet. Relay C operates to close the two-step relay D5. Relay D5 operates to close only its "X" contacts. The rotary magnet advances the wipers one step for each pulse of the series. The off-normal springs ONS close at the first step. Relay C restores at the end of the series to remove operating ground from D5. Relay D5 operates fully, opens the rotary magnet circuit to prevent further rotation and opens an incomplete circuit to relay C.

The wipers of the minor switch are now standing on contacts corresponding to the fifth digit dialed. The lower wiper is ineffective in any position because of the open contact on relay G. The upper wiper is effective only on contact 6 (there is no ground on bank contacts 4 and 5 because of break springs on relay D3). When the upper wiper stops on (or passes over), the sixth bank contact, a circuit is closed to H4, providing neither H2 nor H3 was operated as a result of the second digit dialed. Relay H4, when operated, locks its upper winding and directs relay J toward the "+" line instead of toward the "-" line.

(G) Calling Party Replaces Receiver: (Operated; relays A, B, D1, D3, D4, D5, possibly H2, or H3, also ONS). The calling subscriber now replaces his handset in order to permit ringing to start. When the line loop is opened, A restores to open B and close F. Relay F operates, closes B to prevent its release, removes A from the line, extends "-" line through J to resistance battery, extends "+" line to ground at springs of H4, and closes G to the pick-up lead selected by the second digit. If H3 was

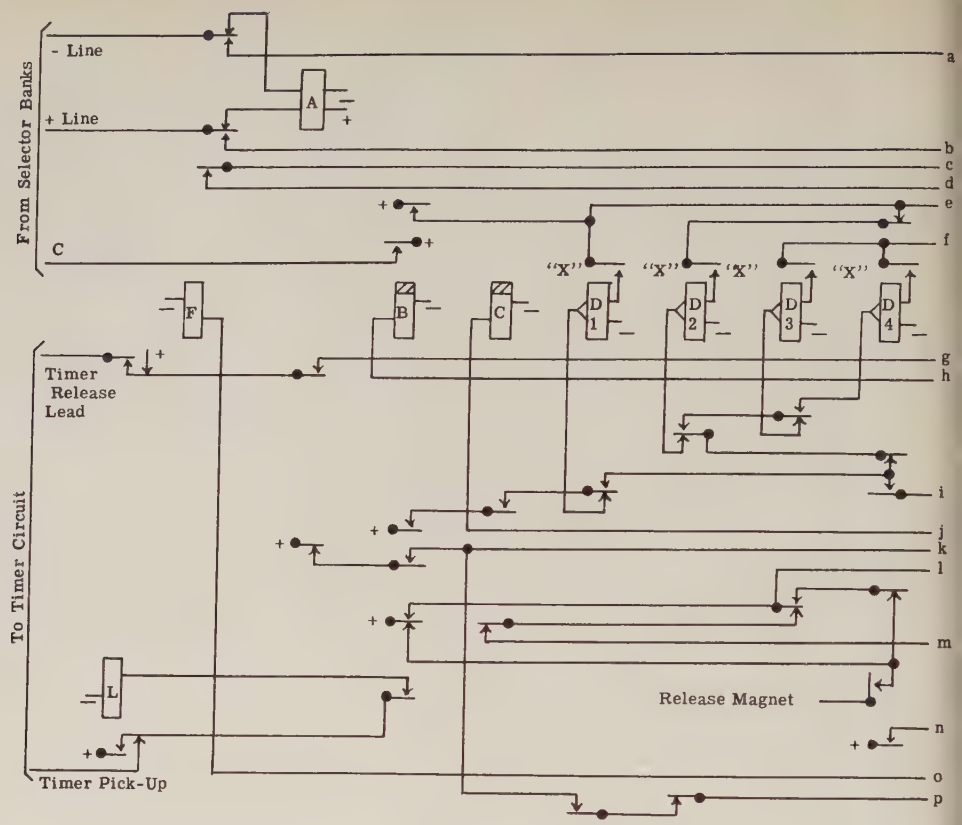



Fig. 1 - Reverting Call, 20-Party, Code Ringing. (Repeated)

operated on the second digit, "pick-up 2" is used, otherwise "pick-up 1".

(H) Ringing Called Station: (Operated; relays B, D1, D3, D4, D5, F, possibly H2, or H3, also ONS). Relay G energizes on the next pick-up pulse (this pulse precedes the start of the code selected by the 5th digit, which is one of the codes in the group selected by the second digit). Relay G operates, locks up to holding ground (ground will be removed from this lead at the completion of the code), and closes K to the selected code lead. Relay K follows the ground pulses on the code lead and extends direct battery connected generator through J to "-" line. When divided ringing is employed, the ringing circuit is completed by way of ground at the called station. In the case of bridged ringers, the circuit is completed at springs of H4. The code will keep repeating until a receiver is removed, or the call is "timed out".

The calling party listens to the code if he chances to be on the same side of the line as the called party. When the ringing stops, the calling party removes his receiver to talk with the called party who, by answering, has cut off the ring. If the calling party is on the other side of the line, his bell will not ring. The calling party must then wait a reasonable time to allow the called party to answer, then remove his handset. If the called party is not on the line, the calling party should hang up momentarily, then repeat the call.

(I) Called Party Answers: When the called party answers, the direct current path causes the energization of J. Relay J operates to close E. Relay E operates, (1) locks up, (2) places reverting call tone on the line to advise the called party that this is a reverting call and that it would be well for him to wait for the calling party to come in on the connection, and (3) extends the reverting time pulse lead to relay H1. Relay H1 operates, locks itself up and transfers B to the time cut-off lead. The time cut-off lead supplies holding ground for a short interval. Relay B restores when ground is removed from the time cut-off lead, removes ground from the C lead to release preceding switches, removes holding ground from various relays in this circuit and closes the release magnet of the minor

RINGING CHART

| Second Digit Dialed | Third Digit Dialed | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| "3" | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 |
| Code Group Selected | #1 | #1 | #1 | #1 | #1 | #1 | #1 | #1 | #1 | #1 |
| Side Of Line Selected | - | - | - | - | - | + | + | + | + | + |
| "4" (H2 Operated) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 |
| Code Group Selected | #1 | #1 | #1 | #1 | #1 | #1 | #1 | #1 | #1 | #1 |
| Side Of Line Selected | - | - | - | - | - | - | - | - | - | - |
| "5" (H3 Operated) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 0 |
| Code Group Selected | #2 | #2 | #2 | #2 | #2 | #2 | #2 | #2 | #2 | #2 |
| Side Of Line Selected | - | - | - | - | - | - | - | - | - | - |

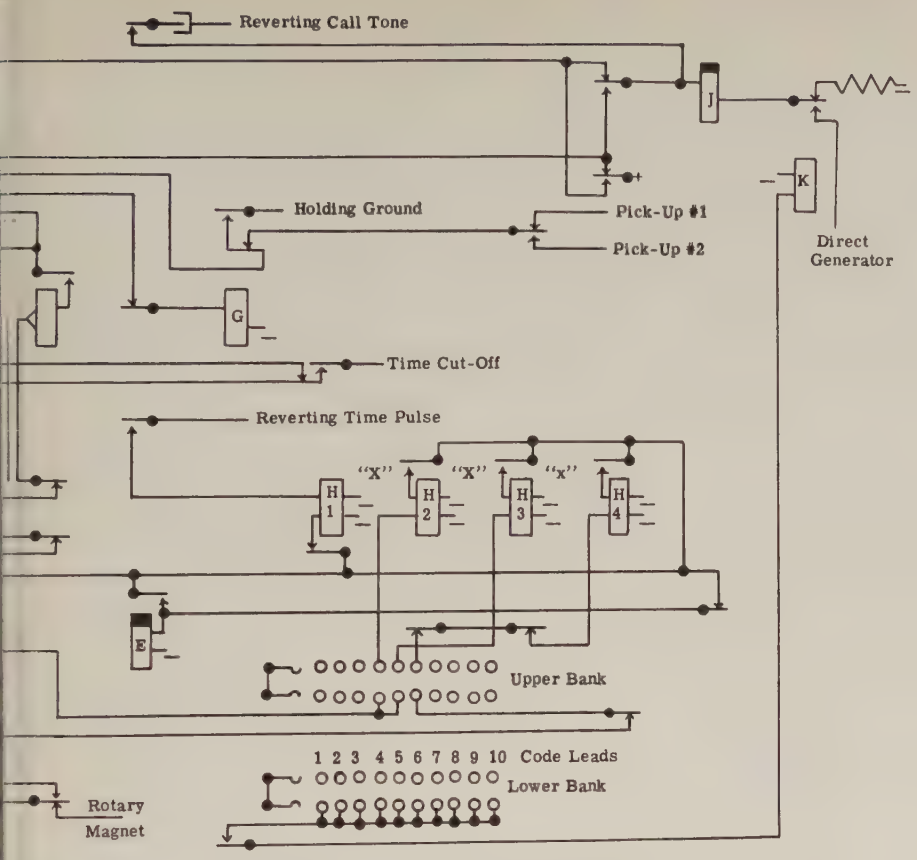



Fig. 2 - Reverting Call, 20-Party, Code Ringing. (Repeated)

itch. The connection releases, and transmission ttery is fed to the calling and called parties from ir line lock-out equipment, see Section 401(f).

"Timing Out": When this switch is seized, relay B sses L to the timer pick-up lead. The next ground se on the timer pick-up lead will close L. Relay L rates, locks up locally, removes local ground from a ring of relay A, and replaces it with ground on the er release lead. After a prescribed internal, ground momentarily removed from the timer release lead, ereupon relay B restores and the connection drops lk to the line lock-out equipment.

Recapitulation: The code ringing scheme described ve is quite involved, and perhaps the accompaning inging Chart" will be helpful. When the second digit lled is "3" (or any digit other than 4 or 5), the first e codes of group #1 will ring on the "-" side of the , and the second five codes will ring on the "+" e of the line. This provides 10-party divided ringing.

en the second digit dialed is "4", all ten codes of the st group ring on the "-" side of the line. When the ond digit dialed is "5", all ten codes of the up ring on the "-" side of the line. The twenty gers must be bridged across the line, for it would er do to "unbalance" by having twenty ringers dged from the "-" side of the line to ground.

Lock Pulsing: Twenty ringers, even if "high pedance", when bridged across a line distort the lse ratio" (see Section 141). Therefore this reverting call circuit actually employes a "lock pulsing" scheme (see Section 322). The lock pulsing feature is not shown here as the circuit is complicated enough as it is.

419 Reverting Call By Directory Number: A circuit analysis of a reverting call by directory number was given in Section 415(c)(J).

420 Connectors Peculiar To PABX's: A general discussion of this subject will be found in Section 175. When a PABX is large enough to employ selectors, the various special services are taken from selector levels and the connector remains fairly simple. But when the PABX is a "connector system" things begin to get complicated. In general there are two types of PABX connectors, (1) Impulse Repeating, and (2) Switching Through.

421 Impulse Repeating on OGT Level: The connector we are about to analyze provides the following special features, (1) Trunk Hunting Service on OGT (Outgoing Trunk Level), (2) Watchman's Service, see Section 174, (3) Code Call Service, see Section 128, and (4) "Meet-me" Conference Service, see Section 131(a), (5) Night Number Service, and (6) Annunciator Service.

421(a) Code Call Service: When code call service is provided, the code call equipment is connected to the tenth bank contact on a certain level, usually the seventh. A party, wishing to call someone over the code call system, dials the 4-digit code call number assigned to that party. The first two digits (70) cause the connector

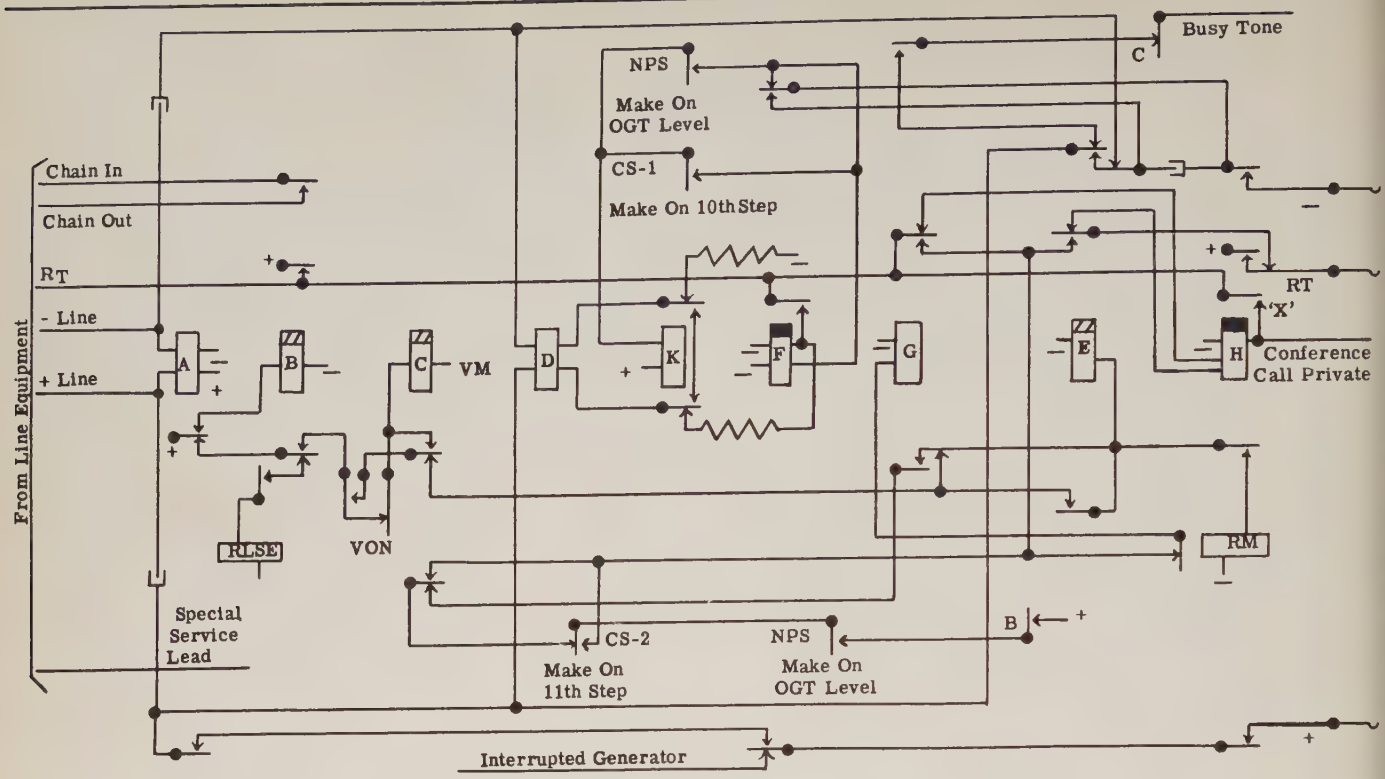



Fig. 1 - Connector, Repeating On Trunking Level.

shown in Figure 1 to advance its wipers to the code call terminals, and the last two digits (repeated by this switch) cause the code call equipment to operate the code call signals. The called party answers by dialing a two digit "answering" number from any telephone.

(A) Seizure: This switch is marked free to the line equipments by the absence of ground on the C conductor. Line relay A operates over the loop to close B. Relay B operates to ground release trunk RT to hold the line equipment, and closes the chain contacts. The chain is here used to stop the master switch when all trunks are busy. See Section 402(b).

(B) Vertical and Rotary Movement: (Operated; relays A and B). Relay A follows the first series of dial pulses and, through its back contact, closes C and the vertical magnet in series. Relay C operates and prepares an alternative circuit to the vertical magnet. The vertical magnet raises the shaft and wipers to the dialed level. The off normal springs operate on the first step and transfer the impulsing circuit through a make contact on C. After the last impulse of the series, relay C restores and transfers the impulsing circuit from the vertical magnet to the rotary magnet.

Relay A follows the impulses of the second series and closes E and the rotary magnet in parallel. Relay E operates, (1) removes lower H from the RT wiper so that H will not operate and open the impulsing circuit when the RT wiper passes over free lines, (2) connects G to the RT wiper, and (3) short circuits break contacts on G so that the impulsing circuit will not be opened as the RT wiper passes over busy lines. The rotary magnet advances the shaft and wipers to the dialed line.

We will assume that the digits 70 have been dialed and that the wipers are in engagement with the code call bank contacts. Cam springs CS-1 (see Section 203 for mechanical arrangement of cam springs) operated on the 10th rotary step and closed lower F in series with K. Relay K operates, removes resistance battery and resistance ground from impedance D, and connects the two windings of D in series. Relay F operates, locks up to release trunk ground, and prepares certain circuits.

(C) Testing The Code Call Circuit: (Operated; relays A, B, E, K and F, also VON and CS-1). When the code call circuit is busy, relay G is closed from ground at the RT wiper. Relay G operates, (1) opens a part of the incomplete circuit to E and the rotary magnet to prevent further rotation, (2) opens lower H to prevent its operation if the dialed line becomes free, and (3) locks to release trunk ground. Relay E restores after the second series of impulses, disconnects G from the RT wiper so that this switch will not prevent the release of a connection to or from the dialed line, and places busy tone on the calling line.

(D) Code Call Circuit Free: If the code call circuit is free, resistance battery at the RT wiper passes through lower H to release trunk ground. Relay H operates, locks its upper winding, places direct ground on the RT wiper, opens the rotary magnet circuit to prevent further rotation, and closes the loop to the code call equipment by bridging impedance D across the "-" and "+" wipers.

(E) Repeating Impulses (Operated; relays A, B, E, K, F, H, also VON and CS-1). Relay A follows the impulses of the code digits and, when at normal, opens the loop ahead and closes E. Relay E, operated during each series of impulses, provides a low resistance loop to

rrove impulsing. The code call equipment responds ne two series of impulses, and causes the proper e to be sounded.

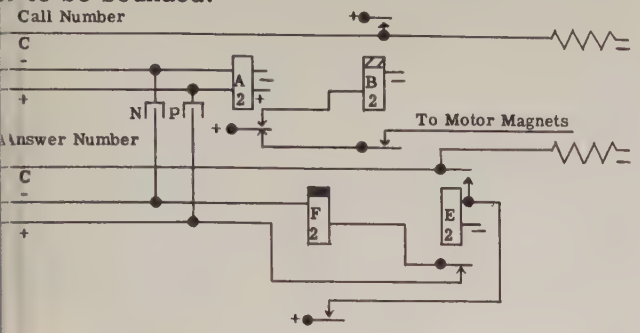



Fig. 2 - Partial Code Call Circuit

party paged by the code goes to any telephone and s the "answering" number, usually 79. The ring ut off by the direct current flow through F2 shown in ure 2. Relay F2 operates to close E2. Relay E2 rates and locks up to ground on the C lead. The ing party receives talking battery from the line relay he calling connector, the called party receives talking ery from the line relay of the answering connector, conversation takes place through condensers N and P. s two connectors and the code call equipment are held during conversation. Each party controls the release he connector he is using.

(b) "Meet-Me" Conference Service: A telephonic ference may be held by arranging to have the inter- ed parties dial the conference number at a pre- anged time or signal. Conference service is provided on the tenth bank contact on a certain level, usually sixth. The "-" and "+" conference line is multipled m bank to bank, but the "private" (third conductor) is so multipled. The conference call private contact in h bank is connected to the conference call private lead he connector having access to that bank, thus making ossible for any connector to switch through on the ference number at any time.

e seizure, and response to the dialed digits is the same described above in Section 421(a).

ay E restores after the series of impulses to the ary magnet and extends release trunk ground through er H to upper RT. As wiper RT is now standing on individual bank contact which is wired back to the nference call private" conductor of this switch, upper ay H operates to lock itself up and extends the talking cuit to the "-" and "+" wipers.

ansmission battery is fed the calling party by relay A. hen the calling subscriber replaces his receiver, ay A restores to release this switch in the usual nner.

(c) Night Number Service: When night number vice is used, all incoming calls during a predetermined iod have access only to a trunk connected to the tenth nk contact on a certain level, usually the fifth. Across night number trunk is connected a ringer which ctions whenever an incoming call is established. Any ty desiring to answer an incoming call dials the night mber.

The seizure and response to the dialed digits is the same as described above in Section 421(a).

Relay E restores after the series of impulses to the rotary magnet and extends lower H to wiper RT. Relay H operates from resistance battery on the contact engaged by wiper RT, lock its upper winding, places direct ground on wiper RT, and bridges impedance D across the "-" and "+" wipers to stop the ring.

Transmission battery is fed to the calling party from relay A. When the calling party replaces his receiver, relay A restores to release this switch in the usual manner.

421(d) Watchman's Recording Service: Each line equipment assigned to watchman's service has a fourth conductor which is wired to the recording equipment associated with that particular line. Operation of such line equipment extend the fourth conductor to a connector (Figure 1), where it is designated the "special service" lead. A two digit call number (need not be the last contact in a level) is reserved for Watchman's Recording Service. The private bank contacts associated with this number are not multipled from switch to switch. The watchman's service private contact in each bank is connected to the "special service" lead of the connector having access to that bank.

A watchman, when reporting from a station on his route, merely lifts the handset, dials the watchman's recording number, and then replaces the handset. The seizure and response to the dialed digits is the same as described above in Section 421(a).

Relay E restores after the series of impulses to the rotary magnet and extends lower H to wiper RT. Relay H operates from resistance battery on the special service lead, locks its upper winding, and grounds the RT wiper to cause the watchman's recording equipment to register the call. The connector releases when the handset is replaced at the calling telephone.

421(e) Trunk Hunting on OGT Level: Trunk hunting service is arranged for on the "0" level of this switch. The normal post springs (NPS) make on the tenth vertical step. The seizure, and response to the first series of impulses, is the same as described above in Section 421(a). When the normal post springs operate on the 10th step, K is closed in series with lower F, and G is energized before E restores.

Relay K operates, removes resistance battery and resistance ground from impedance D, and connects the two windings of D in series. Relay F operates, locks its upper winding and prepares various circuits. Relay G operates, locks up to release trunk ground and prepares the "automatic rotary" circuit.

(A) Automatic Cut-In: (Operated; relays A, B, C, K, F and G, also VON and NPS). Relay C restores after the first series of dial impulses, opens the starting circuit to G, and closes E in parallel with the rotary magnet. Relay E operates and connects G to the RT wiper. The

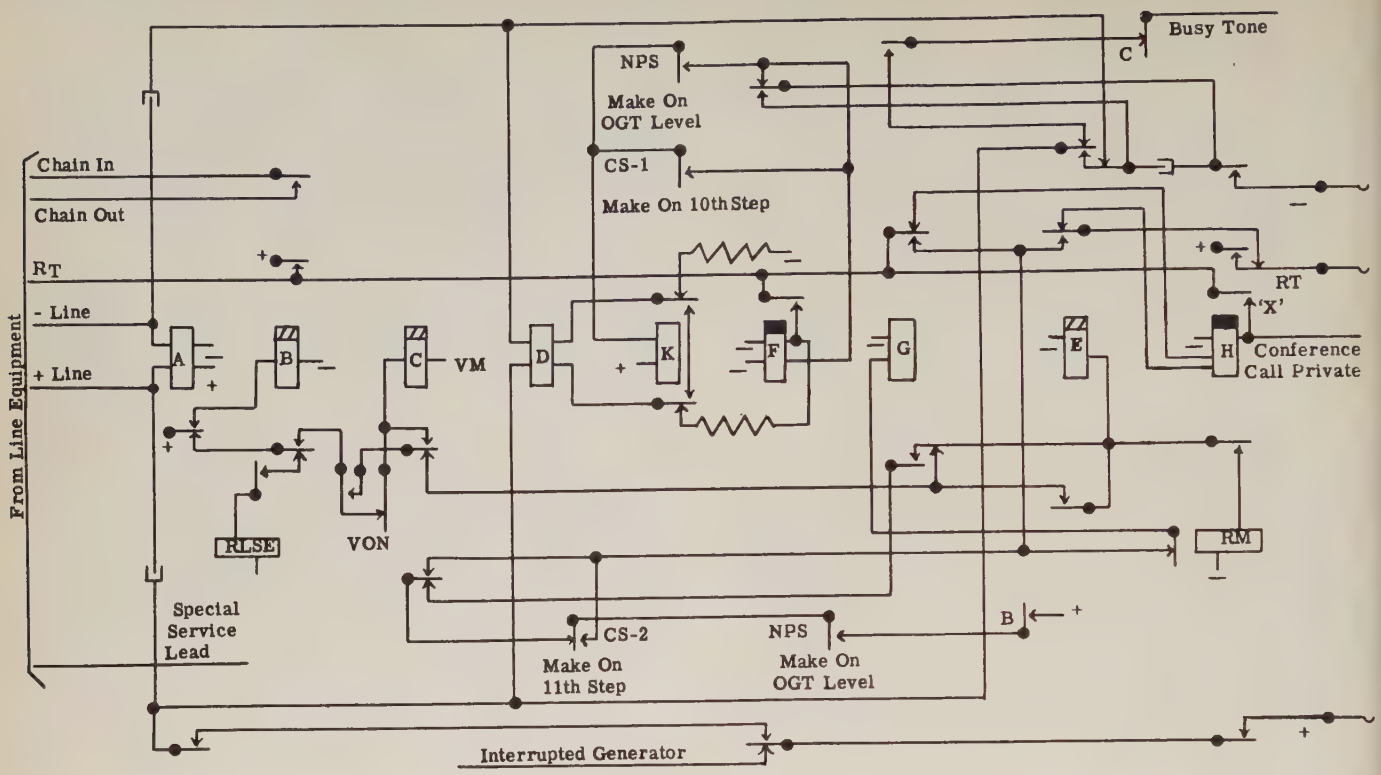



Fig. 1 - Connector, Repeating On Trunking Level. (Repeated)

rotary magnet operates to advance the wipers to the first trunk and opens G. Relay G restores and opens E and the rotary magnet.

(B) Searching For Idle Trunk: When the first trunk is busy, the rotary magnet restores to close G to wiper RT. Relay G operates, closes its locking circuit to insure complete operation of the rotary magnet when a free trunk is found, and closes E and the rotary magnet. The rotary magnet advances the wipers one step and opens G. Relay G again restores and opens E and the rotary magnet. The foregoing operations continue until a free trunk is found or the wipers pass off the bank. Relay E remains operated during rotation.

(C) Seizing First Idle Trunk: When a free trunk is reached, the wipers come to rest and G remains at normal since there is no ground on the RT wiper. Relay E now restores and closes lower H to resistance battery via the RT wiper. Relay H operates, locks its upper winding, places direct ground on the RT wiper, and closes the trunk loop through impedance D.

(D) Repeating Impulses: (Operated; relays A,B,K, F and H, also VON and NPS). Relay A follows the impulses of each subsequent series and, when at normal, opens the trunk loop and closes E. Relay E, operated during each series of impulses, provides a low resistance loop (rather than impedance D) to improve impulsing. The opening and closing of the trunk loop causes the switches ahead to complete the desired connection.

Transmission battery is fed the calling party by relay A. When the calling party replaces his receiver, relay A restores to release this switch in the usual manner.

(E) All Trunks Busy: If all the trunks on the level are busy, the shaft takes an eleventh rotary step to move the wipers off the bank and operate certain cam springs. Said cam springs open an incomplete circuit to E and the rotary magnet (so they cannot re-operate), and close G. Relay G operates, locks up, and places busy tone on the calling line.

421(F) Annunciator Service: Each line equipment which is to receive annunciator service has a fourth conductor wired to the corresponding drop on the annunciator board. Operation of such line equipment extends the fourth conductor to a connector (Figure 1), where it is designated "special service" lead. A two digit call number (need not be the last contact in a level) is reserved for Annunciator Service. The private bank contacts associated with this number are not multipled from switch to switch. The annunciator service private contact in each bank is connected to the "special service" lead of the connector having access to that bank.

A party, permitted messenger service, merely lifts his handset, dials the annunciator service call number, and then replaces his handset. The seizure and response to the dialed digits is the same as described above in Section 421(a).

Relay E restores after the series of impulses to the rotary magnet and extends lower H to wiper RT. Relay H operates from resistance battery on the special service lead, locks its upper winding, and grounds the RT wiper to actuate the annunciator drop. The connector releases when the handset is replaced at the calling station.

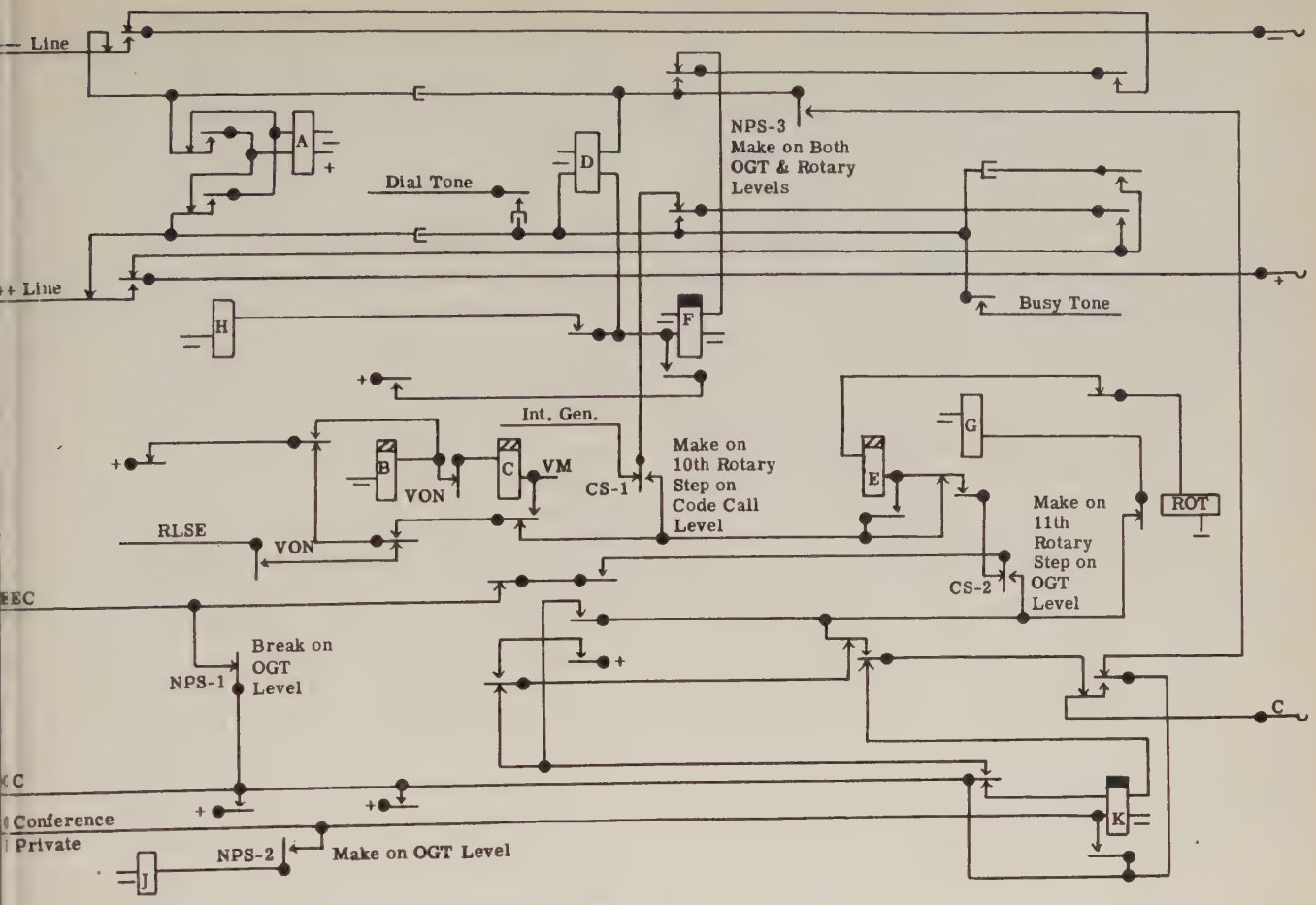



Fig. 2 - Connector, Switching Through On Trunking Level. (Repeated)

Switching Through: In the section just above we cussed a connector having two major functions, complete connections from station to station, and extend connections to the first idle outgoing trunk the "0" level. When operating on the "outgoing nk level" that connector operated as an impulse eater.

connector circuit shown in Figure 2 has three major ctions, (1) complete connections from station to tion, (2) complete connections from a calling station he first idle station in a group of stations (as the y says, "hunt-the-not-busy-line"), and (3) extend nections to the first idle outgoing trunk (OGT) to ther office. When operating on the OGT level this nector operates as a selector to "switch through" to repeater associated with the selected trunk. This nector also incorporates the following minor features, Discriminating Service, (2) Code Call Service, and "Meet-Me" Conference Service.

mal post springs NPS-1 and NPS-2 operate on the T level, while normal post springs NPS-3 operate on n the OGT and the rotary level. Certain cam springs ) operate on the 10th rotary step, and other cam ings operate on the 11th rotary step.

(a) Discriminating Service: Calls on regular service els such as, station to station, code call etc., may be de from any line. Calls on the OGT level can be completed only when the line equipment involved has a strap between its C and EC conductors.

422(b) OGT Calls: This switch is marked free to the line equipments by the absence of ground on the C conductor. Relay A operates over the line loop to close B and upper C. Relay B operates to return holding ground on the C lead. Relay C operates to place dial tone on the calling line.

(A) Raising Wipers to OGT Level: (Operated; relays A, B and C). The outgoing trunks are usually reached by dialing the digit "0". Relay A follows the impulses from the dial and, through its back contact, closes upper C and the vertical magnet in parallel. The vertical magnet raises the shaft and wipers to the dialed level. Relays B and C remain operated throughout the series. The off normal springs operate on the first vertical step.

Normal post spring assemblies NPS-1, 2 and 3 operate on the tenth vertical step, NPS-3 closes upper D, NPS-2 prepares the circuit to J, and NPS-1 prepares the discriminating circuit. Relay D operates to close G. Relay G operates and locks up independent of make springs on C.

(B) Discrimination: (Operated; relays A, B, C, D, G, also VON and NPS-1, 2 and 3). When the calling line is denied OGT service, there will be no strap between the C and EC leads at the line equipment. Relay C restores

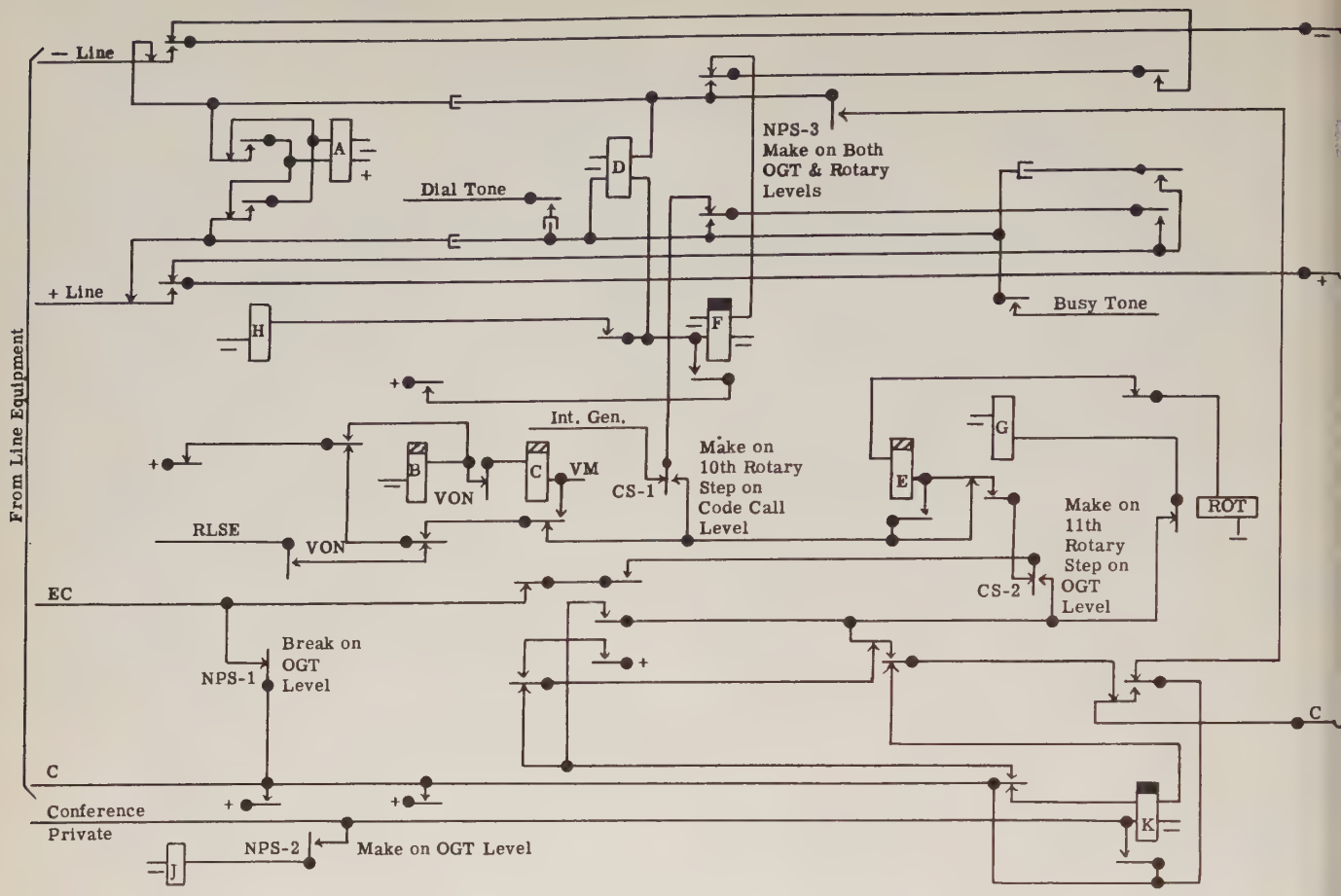



Fig. 1 - Connector, Switching Through On Trunking Level. (Repeated)

after the first series of impulses and cannot again become operated. Since the impulsing circuit to E and the rotary magnet is open at springs of G, further operation of the dial will be without effect. The busy tone, placed on the line by relay G, will inform the calling party that he cannot obtain OGT service. When the receiver is restored at the calling sub-station, relay A restores to open B. Relay B restores and the switch releases in the usual manner.

(C) Calling Line Entitled to OGT Service: Remember that the C lead is grounded at springs of relay B, and that the C and EC leads are strapped at the line equipment of an unrestricted line. It follows then that C, restoring after the first series of impulses, will complete a circuit from ground on the EC lead through E to the rotary magnet. Relay E operates to extend G to the C wiper. The rotary magnet advances the wipers to the first bank contact and opens G. Relay G restores and opens the circuit to E and the rotary magnet.

(D) Search For Idle Trunk: (Operated; relays A, B, D, E, also VON and NPS-1, 2 and 3). When the first trunk is busy, the rotary magnet restores to close G from ground on the C wiper. Relay G operates, closes its locking circuit to insure the complete operation of the rotary magnet when a free trunk is found, and recloses E and the rotary magnet. The rotary magnet advances the wiper one step and opens G. The foregoing operations continue until a free trunk is found or the wipers ar moved off the bank. Slow to release relay E remain operated.

(E) Seizure of First Idle Trunk: When a free trunk i found, absence of ground on the C wiper prevents th re-operate of G. Relay E, upon restoring, closes upper from resistance battery on the C wiper. Relay operates, locks its lower winding, closes J, opens D, an places direct ground on the C wiper.

Relay J operates, opens the impulsing circuit to preven further rotation, extends the line to the OGT, an removes A from the line. Relay A restores to open B Slow to release relay B remains operated until the switc ahead returns ground over the C wiper to hold thi switch and the line equipment.

(F) All OGT Busy: If all the trunks are busy, the switc takes the eleventh step to operate cam springs CS-2 Ground from the EC wiper is passed to G, which operate to place busy tone on the calling line.

(G) Releasing: (Operated; relays K, J, also VON an NPS-1, 2 and 3. When the receiver at the calling statio is replaced, the switch ahead removes ground from th C wiper, thus opening J and lower K. Relay J restore and closes the release magnet. The release magne operates to return the switch to normal.

(c) Hunt-The-Not-Busy-Line: The seizure and rtical motion of the wiper is the same as described ve. When a "rotary level", as distinguished from an GT level" is dialed, only normal post springs NPS-3 operated. There is no discrimination on this level ause the unbroken NPS-1 connects the C and EC leads. search for an idle trunk, and the seizure of the first e trunk is the same as explained above, except the ration of K does not close J because of open NPS-2.

Ringing First Idle Line In The Group: (Operated; ays A, B, K, also VON and NPS-3). The interrupted und connected generator completes a circuit through ringer and condenser at the called station and thence way of upper F to battery. Slow to operate relay F l not respond to ringing current. Part of the ringing rrent is passed to the calling line to afford ring-back ication.

Called Party Answers: Relay F energizes on direct rent when the receiver is removed at the called tion, locks its lower winding, removes generator from called line, and bridges D across the called line. lay D operates to close H. Relay H operates to erse polarity on the calling line. Transmission ttery is supplied to the calling line through A, and he called line through D. Release is under control of calling party.

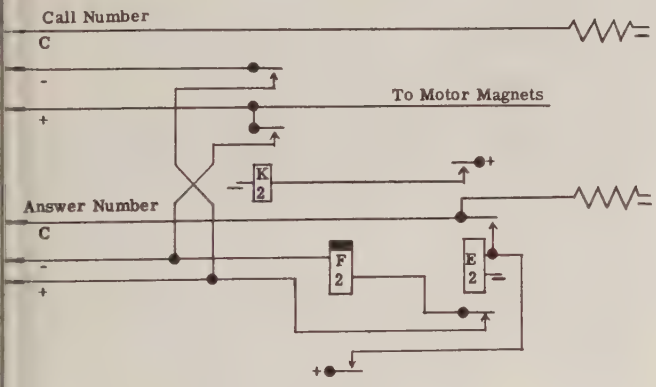



Fig. 2 - Partial Code Call Circuit

(d) Code Call: When the code call number (the tenth ntact in a given level) is dialed, cam springs CS-1 are erated. If the code call equipment is idle, relay K erates from resistance battery on the C wiper and, transfers the pulsing circuit from E and the rotary gnet to the "+" wiper, and (2) extends upper F to the " wiper. Relay A, responding to subsequent digits, ced ground pulses on the "+" wiper, and thence direct the magnets of the code call equipment, see Figure 2. e code call equipment responds thereto and sounds the sired code.

e desired party responds to the code call by dialing the nswer" number (usually 79) from any telephone. The swering connector naturally finds the "answer" mber idle, its relay K operates from resistance battery the C wiper. The ring is cut off by the direct current w through F2. Relay F2 operates to close E2. Relay operates, locks up to ground on the C lead, and closes . Relay K2 operates to extend "-" and "+" of the call multiple to "+" and "-" of the answer multiple, note the reversal.

The reversal causes relay D of the answering connector to energize in series with relay D of the calling connector. Relay D of the calling connector operates to close H. Relay H operates to reverse polarity to the calling line. The calling party receives transmission battery from relay A of the calling connector, the called party receives transmission battery from relay A of the answering connector, and conversation takes place through the multiple. Each party controls the release of the connector he is using.

422(e) Conference Service: This circuit provides for conference service much in the same manner as was explained in Section 421(b).

423 Executive "Right-of-Way": A general discussion of this subject will be found in Section 138.

424 Using Individual Connector: The individual connector analyzed in Section 415(e)(E) connects with the called line whether it is in use or not.

425 Using Common Connector: The common connector discussed in Section 404(i) plumps the executive right in on the called line even though it is busy. This should be distinguished from cases where the executive must do something to "over-ride" the busy condition.

The connector we are about to discuss is interesting because of an unusual impulsing circuit. The circuit

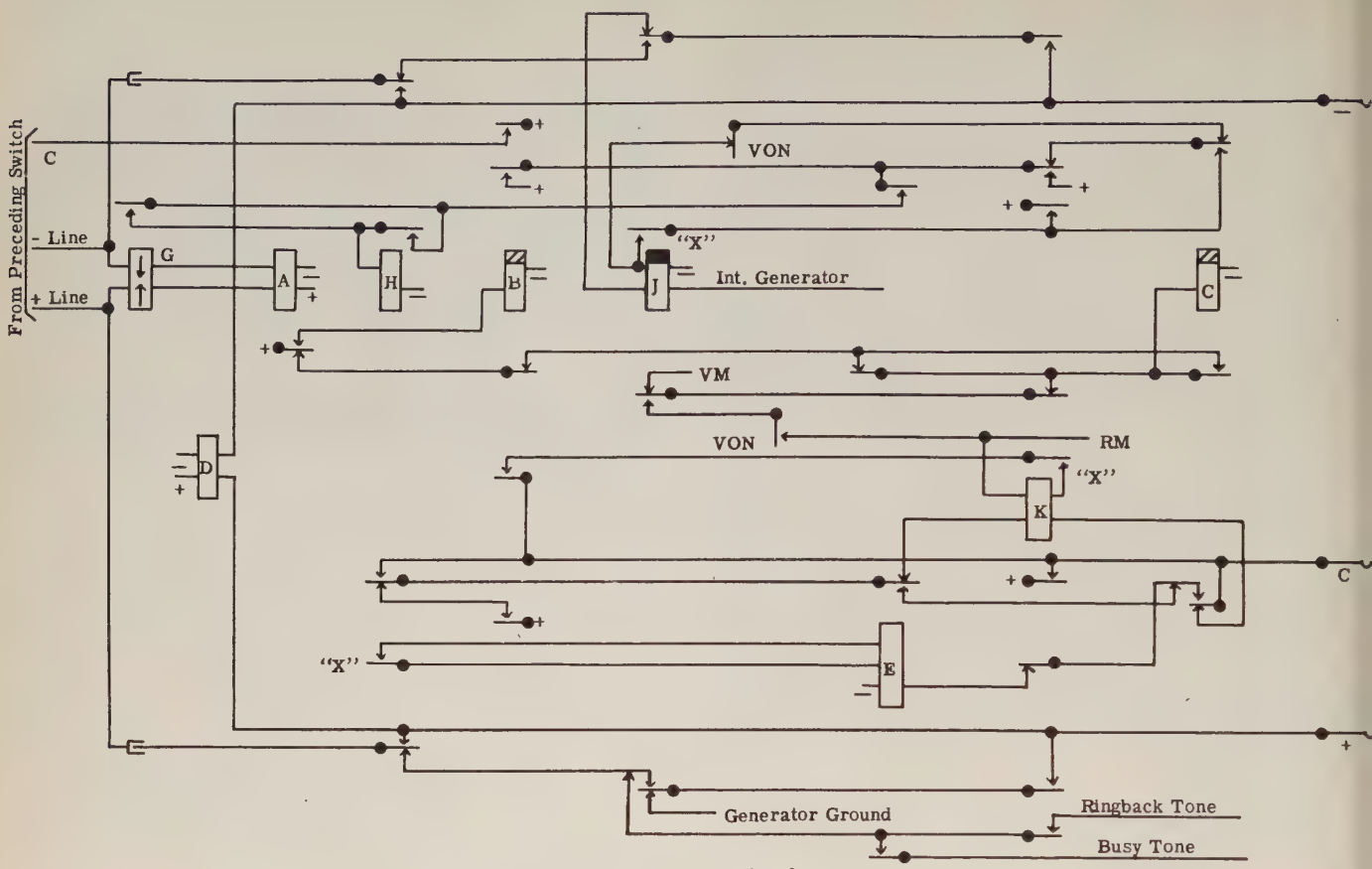



Fig. 1 - Connector, Executive Right-of-Way.

shown in Figure 1 has been stripped of several features such as reverse battery, supy-1, supy-2, release, etc.

(A) Seizure: This switch is marked free in the banks of preceding switches by the absence of ground on the C conductor. The windings of relays A and G are closed over the calling loop. Relay G will not operate because the magnetic fields associated with its windings are in opposition. Relay A operates to close B.

Relay B operates, (1) grounds the C lead to hold the preceding switches operated and make this switch busy, and (2) closes upper J. Relay J operates to prepare a circuit for the vertical magnet.

(B) Vertical and Rotary Motion: (Operated; relays A, B and J). Relay A follows the impulses of the first series and, when at normal, closes C in parallel with the vertical magnet. Relay C operates, locks up independent of break springs relay E, and locks upper J.

The vertical magnet follows the impulses of the first series and raises the shaft and wipers to the dialed level. The VON springs operate on the first step. Relays B and C remain operated during pulsing. Relay C restores shortly after the end of the series and opens J. Relay J restores to extend the pulsing circuit to the rotary magnet.

Relay A follows the impulses of the second series and, when at normal, closes C in parallel with the rotary magnet. Relay C operates, locks up independent of break springs relay E, and extends lower E to the C wiper. The rotary magnet follows the impulses of th second series and advances the shaft and wipers to th dialed line.

(C) Testing Called Line: (Operated; relays A, B and C also VON). If the called line is busy, wiper C will be i engagement with a grounded bank contact, thus closin lower E.

(D) Called Line Busy: Relay E operates, places bus tone on the calling line, and opens the pulsing circuit t prevent further rotation. Relay C, restoring shortly afte the end of the series, locks lower E to ground at spring of relay B, and extends lower K to the C wiper.

(E) "Over-Ride" of Busy: (Operated; relays A, B, E also VON). If the calling party has an executive right of-way telephone, the non-locking push button mounte thereon may be momentarily depressed to place groun on the "-" line lead. This unbalancing of the line circu causes relay G to operate and close H. Relay H operates locks up, removes busy tone from the calling line extends "-" and "+" line to "-" and "+" wipers, shor circuits upper E to make that relay slow to release and transfers the locking circuit of lower E from groun at springs of relay B to ground via the C wiper. Th calling party may now monitor the conversation. H may decide to take part therein, or to "camp-on-busy"

(F) Camp-On-Busy: When the parties on the busy lin disconnect, that line becomes free, and ground now on th

rivate bank contact engaged by wiper C is replaced by esistance battery. Whereupon relay E restores to een H. Relay H restores to place ground on lower K. elay K operates from resistance battery on the C wiper nd the called party is signalled in the customary anner.

) Recapitulation: The accompaning circuit diagrams e widely spaced to permit the student to gain practice filling in deleted features. In general the circuit planations are straight forward, and often times terlocking features are not discussed in full detail. here is a reason for every make and break contact every circuit, see that you know that reason. Mark your books, argue with the writer - he might have en wrong. A text book with no "mark-ups" is a poor vestment. You might even try your hand at writing rcuit explanations. It is not as easy as it looks.

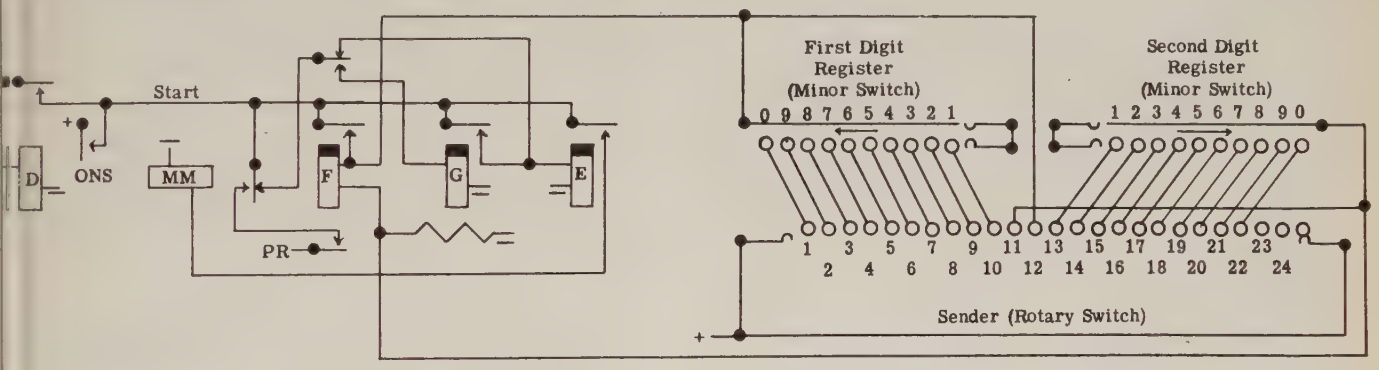



Fig. 2 - Register-Sender, Code Call Switch.

6 Code Call Service: This general subject was scussed in Section 128. Code call service via the nnector was analyzed in Sections 421(a) and 422(d). are here concerned with the code call switch itself. ly a very stream-lined version will be presented, but s will suffice to bring out certain fundamental concepts.

3(a) Register-Sender: Refer to Figure 2 and note the ender" which is indicated as a one level rotary switch. e end of the double-ended wiper is shown standing on 25th (home) position. The movement is from left right.

e second digit register is indicated as a one level nor switch. At each step the bridging wiper connects e upper "common plate" to the individual lower ntact. The movement is from left to right. For the ke of circuit clarity, the first digit minor switch is licated as moving from right to left.

is is a 100-code, two digit, register-sender. The ortest possible code is 1-1, the longest 10-10. Note t the first digit register "marks" the sender contacts reverse, that is, "1 to 0" becomes "10 to 1". The cond digit register marks straight, that is "1 to 0" rks "13 to 22".

en the sender leaves home position it steps rapidly il the first marked contact is reached. The stepping n slows down and, at each step, a power relay erates to impress commercial power on a code call circuit which extends throughout the area. When contact "11" is reached, the power relay is rendered inoperative. The next step has the same circuit effect as had the first marked contact. The slow stepping continues until the second marked contact is reached. The circuit effect here is the same as that which occured on contact "11", the switch now resumes high speed stepping and the cycle repeats until the code call signal has been answered.

The interval between the two digits of all codes is the same, since it is determined by steps 11 and 12. The interval between a given code and its repetition is a variable, determined by the "running time" from the marking of the second digit to the marking of the first digit. Obviously the interval between code 1-1 and its repetition is greater than in the case of code 10-10.

This register-sender theory is fundamental, and has far wider application that merely code call service.

426(b) Seizure: We are not concerned here with how the code call switch is reached, or how the code call is answered. Assume, (1) that a connection has been extended to this switch, (2) that the pulses of the first digit dialed into this switch have advanced the first digit register a number of steps corresponding thereto, and (3) that the pulses of the second digit have advanced the second digit register a corresponding number of steps.

426(c) Operation of Sender: Assume further that the circuit of D is closed after the completion of the second series of impulses, and that it will remain closed until the code call has been answered. Relay D operates to ground the start conductor, thus closing slow to operate E. Relay E operates to close the motor magnet of the sender. Motor magnet MM operates to open E. Relay E restores to open MM. Motor magnet MM restores, closes E and advances the wiper of the sender switch one step. This cycle continues, and the sender advances at high speed until -

When the finder switch wiper reaches the contact marked by the first register, ground is extended to F and thence through a limiting resistance to battery. Relay F operates, locks up to the start conductor and closes G. Relay G operates to close E. Relay E operates to close MM. Motor magnet MM operates to open G. Relay G restores to open E. Relay E restores to

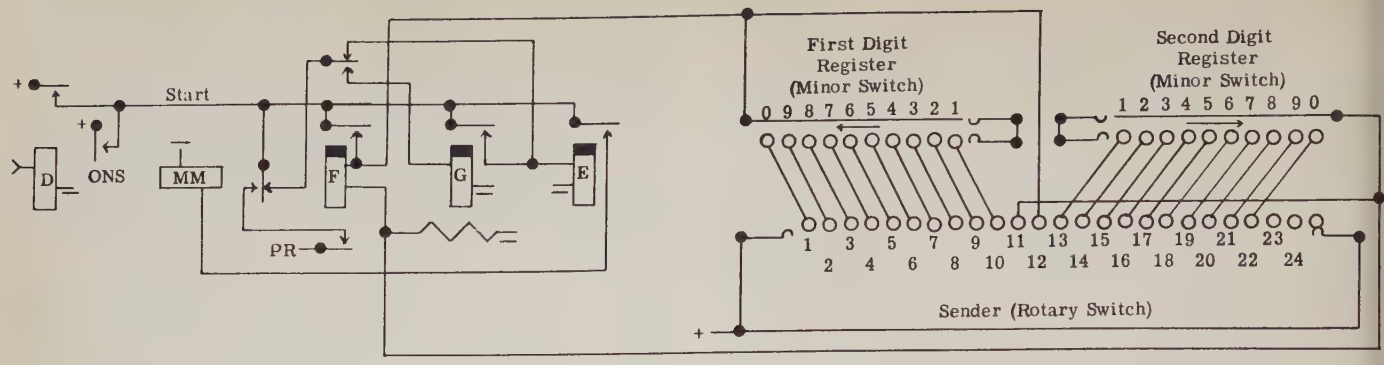



Fig. 1 - Register-Sender, Code Call Switch. (Repeated)

open MM. Motor magnet MM restores, closes G and advances the wiper of the sender switch one step. This cycle continues, and the sender advances at reduced speed until -

When the finder switch wiper engages contact "11", F is shunted down by direct ground on its lower terminal. Relay F restores and closes E. Relay E operates and closes MM. Motor magnet MM operates to open E. Relay E restores to open MM. Motor magnet MM restores to advance the wiper of the sender to contact 12, thereby closing F. Relay F operates to close G and the slow speed cycle is resumed until -

When the sender switch wiper reaches the contact marked by the second register, F is shunted down by direct ground on its lower terminal. Relay F restores and closes E, and the high speed cycle is resumed until the wiper of the sender again engages the contact marked by the first digit register.

426(d) Answering Code Call: Note that the power relay PR is operative only when MM and F are energized simultaneously. The code cycle continues to repeat until the code call is answered, whereupon relay D restores. The restoration of D will not stop the sender in the middle of a code, because the off-normal springs ONS of the sender open only when the sender is in home position (wiper engaging the 25th contact).

426(e) Recapitulation: As mentioned above, this presentation has been very much stream-lined, the actual circuit from which it was taken employed sixteen relays. The alert reader will detect several "partials", and will wonder how the circuit can be made to operate. The answer is, of course, that the relays used must be carefully selected and accurately adjusted.

It really takes two kinds of men to perfect an electro-mechanical device. First the circuit designer who has the vision necessary to think out things that have never been done before; and second, the technician who knows the characteristics of relays and mechanisms. It is strange that so few technicians ever develope into designers.

Perhaps not so strange, for there is a striking parallel in the musical world. One who listens to a symphony at an orchestral concert should realize that the composer drew on his inspiration to fill pages with symbols, and that the conductor and his musicians interpret these t bring to life again what was in the composer's mind It has been said that Beethoven often wrote impossibl horn parts, only to find some "horn tooter" who woul learn how to execute the passage. Yet few horn tooter ever learn to compose as Beethoven did.

427 Conference Service: A general discussion of thi subject will be found in Section 131.

427(a) "Meet-Me" Conference: The circuit arrange ments necessary for this type of conference servic were analyzed in Section 421(b).

427(b) "Fixed Group" Conference: This service ca best be explained by discussing a special application "Crash Alarm". Refer to Figure A and assume tha the control station telephone is located in the contro tower of an airport. The equipment at the control statio consists merely of a manual telephone instrument and bank of lamps, one lamp for each station in the fixe group (fire department, ambulance, etc.).

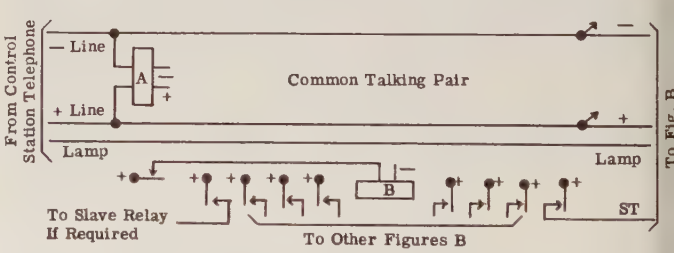



Fig. A - Fixed Group Conference.

The line circuit terminates in the battery feed relay A and the talking pair is multipled to each station in the group. Relay A controls the gang relay B, which mount a pair of springs for each station in the group. There i also an individual lamp conductor for each station i the group.

Refer now to Figure B and note that the station telephone line passes through back contacts of relay H, and thence to the associated line equipment. Incoming and outgoing calls are made in the usual manner. The equipmen shown in Figure B is individual to each station i the group.

(A) Seizure: When the handset is removed at the contro station to report an imminent crash, relay A operates t close B. Relay B operates to place ground on the

art lead ST of each station in the group. One relay B usually not sufficient, therefore the first relay B oses the circuit of the next relay B, and so on.

) Ringing All Stations: Ground on the individual art lead closes H. Relay H operates (1) to disconnect e line equipment (and also the "closed" negative d positive normals, note that the "C" normal is ounded to make this station busy in the connector nks), (2) places direct battery connected generator on e negative line by way of lower F, and (3) places rnerator ground on the positive line. Note the "forced sconnect", relay H operates even though the station ay be making or receiving a call.

ne un-interrupted generator causes a continuous ring at l stations, this serves as an emergency alarm. As ch station answers, the resulting direct current flow uses the energization of the associated F relay. lay F operates, (1) locks its upper winding to ground the start lead and/or springs on relay H, (2) removes ow to release relay H from the start lead, and ) extends the station line to battery feed relay D and e common talking pair. Relay D operates to ground the mp lead as an indication that this station has answered, d re-grounds relay H.

) Transmission: A transmission circuit is now mplete between the control station and the called ation or stations by way of the condensers in each ation circuit. Relay A furnishes transmission battery the control station, while the individual relays D rnish transmission battery to their respective stations.

) Release Of Individual Station: Any station may tire from the conference at will. The opening of the ne loop causes D to restore and open H. Relay H estores and re-connects the station to its line equip- ent. Relay F is held from ground on the start lead.

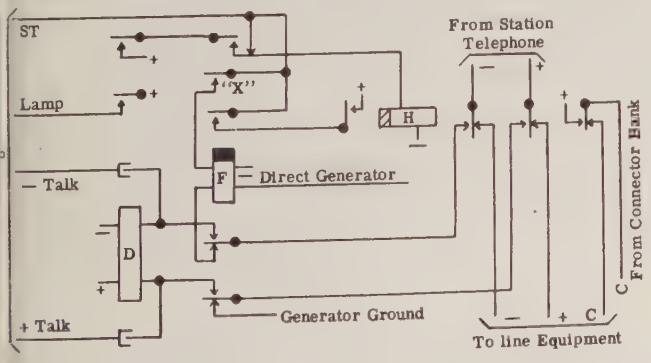



Fig. B - Fixed Group Conference. (Repeated)

E) Release Of Control Station: When the control tation releases first, the loop is opened to A. Relay A estores and opens B. Relay, or relays, B restore and emove ground from all the start leads. Each station quipment will remain operated until the associated andset is restored.

CONTINUED FROM PAGE 161

Later Discoveries: True science is based on reproducible observations or experiments or both. The necessity of clearly separating theory from fact. Facts are permanent and reliable. Theories change from age to age and are not to be trusted beyond the field of experiment.

There are no scientific means to discover the real nature of God, the Creator, what he desires man to be and to do, or what he expects to do with us after this life. Such truth must be revealed by God to man, there is no other way.

The Hebrew scriptures, the Bible, are that revelation, to be accepted at face value by faith.

Any collective action by a group of people requires organization, with various responsibilities placed on several men, each of whom must lead the actions of the rest in his sphere of responsibility. This involves not slavish obedience but intelligent co-operation. There must be a reasonable respect for such constituted authority - without it there can be no useful human organization.

My Experience: Every youthful objective on earth has been and is being realized. Engineering work continues to be a joy and a delight, there is no "daily grind". My relations to those under whose leadership I have worked, past and present, have not been and are not now those of master and slave, but of co-operation with mutual respect.

The Christian woman whom God gave me has been and is a worthy companion and wonderful mother. She has never become commonplace, but retains her charm of character. Our children are true Christians and are respected by their associates.

My family and I have never lacked for the necessities of life and the pleasures of friendships, literature, music, art, and physical exercise.

Fellowship with the Lord Jesus Christ has become increasingly sweet and satisfying with the years. He has never failed me.

My case is not an unexplainable exception, but is the uniform experience of all who follow the above formula (Early Training and Objectives in Life).

It is a pleasure, a joy, to set down these objectives and principles and my long experience in living according to them. To the Lord Jesus Christ is all the thanks and praise for what He has done for me and mine.

Arthur Bessey Smith
1946 January 7.

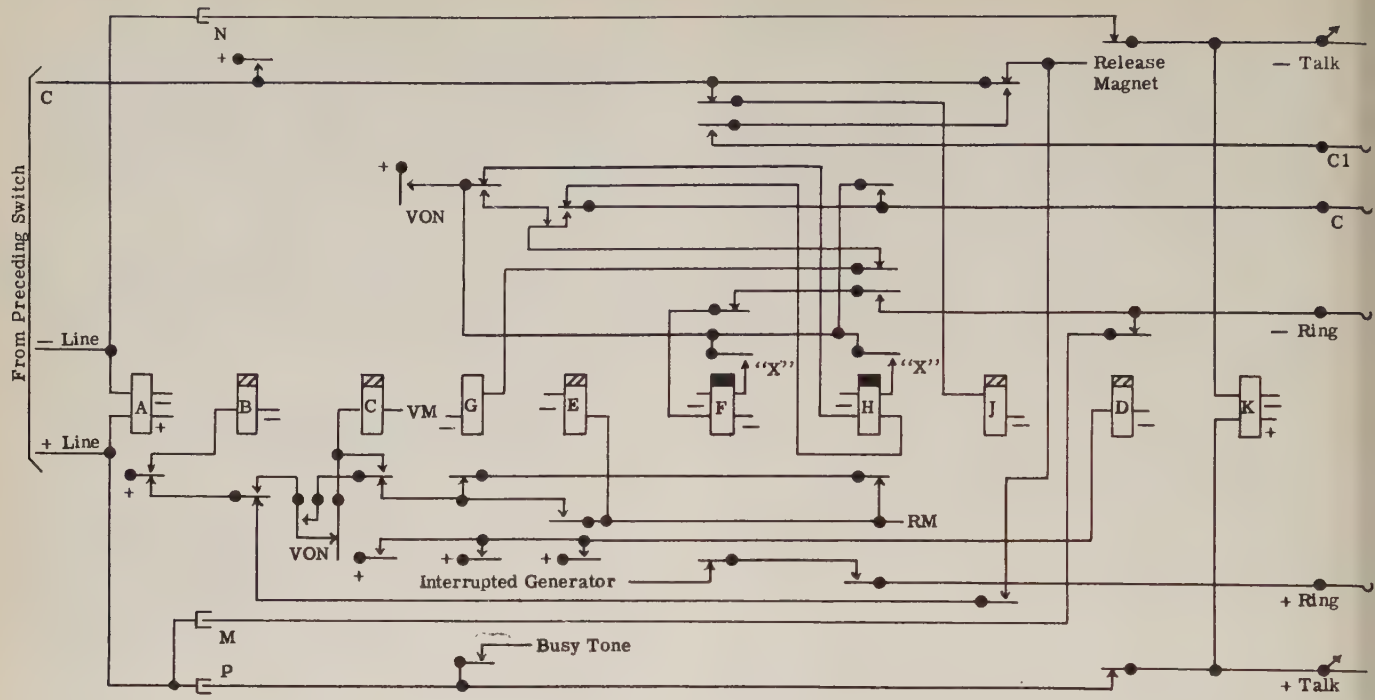



Fig. B - Progressive Conference Connector.

427(c) "Progressive" Conference: The connector we are about to discuss is a very special "drop-back" switch. It responds to two digits in the usual manner then, when the called station answers, the connector only restores to normal so that another number on the progressive list may be dialed.

Refer now to Figure A, which shows the special equipment that must be associated with each station on the progressive list. Note that the two line conductors are shown wired to associated line equipment and regular connector terminals in the usual manner. There is a relay L and four special connector terminals for each station on the progressive list. The "-" and "+" talk conductors are multipled to each station on the list.

It is obvious that a single Conference Call Connector can serve a maximum list of one hundred stations. There need be no association between the directory number of a given station and its appearance in the bank of the Conference Call Connector. The term "progressive" is somewhat mis-leading, the stations on the list may be called in any sequence.

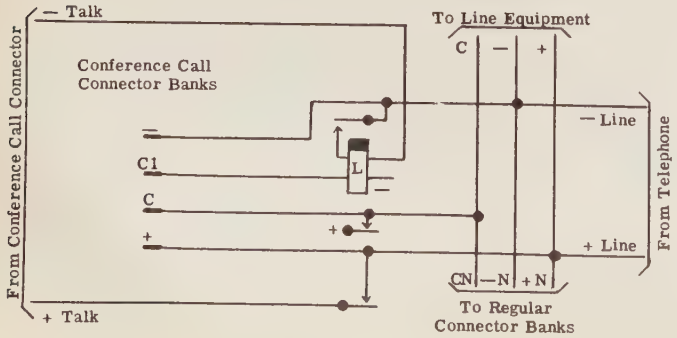



Fig. A - Progressive Conference.

Refer now to Figure B and note the two control wipers C and C1. The "-" and "+" ring wipers are used only t signal the called station. The switch returns to norma as soon as the called party answers. The "-" and "+" talk conductors are multipled to each Figure A equipment

(A) Seizure: This switch may be seized by a selector o a switching through connector. Its seizure is in no wa limited to those stations on the progressive list. Upo closure of the line loop, relay A operates to close B Relay B operates, grounds release trunk C to hol preceding switches, and closes J. Relay J operates but without effect at this time.

(B) Vertical and Rotary Motion: (Operated; relays A B, and J). Relay A follows the impulses of the firs series and, when restored, closes C in series with th vertical magnet. Relay C operates, prepares its holdin circuit, and closes D. The vertical magnet operates t raise the shaft and wipers to the dialed level. Th vertical off-normal springs operate at the first step t transfer the impusling circuit. Relay D operates to clea the common talking circuit from condensers M and N the purpose of this feature will become apparent later Relay C remains operated until shortly after the end o the series.

Relay A follows the impulses of the second series and when restored, closes E in parallel with the rotary magnet. Relay E operates, locks up independent o break springs on G, closes D, and extends G to th C wiper. Relay D operates without effect. The rotary magnet operates to advance the shaft and wipers to th dialed station.

(C) Testing Called Line: (Operated; relays A, B, J, E, D also VON). In the event the called line is busy, wiper C will extend ground to busy relay G. Relay G operates

opens the impulsing circuit, closes a multiple circuit to D, places busy tone on the calling line, removes ground from lower H to prevent its operation should the called line become free, and prepares its own locking circuit.

Relay E restores shortly after the end of the series, closes a holding circuit for relay G, and opens D. In the event busy tone is received, the calling party must restore his handset and release the complete switch train. This operation is quite standard and need not be discussed.

(D) Called Line Idle: (Operated; relays A, B, J, E, D, also VON). In the event the called line is idle, wiper C extends resistance battery (after E restores) through lower H to VON ground. Relay H operates, opens the rotary magnet circuit to prevent further rotation, locks its upper winding to VON ground, places direct ground on the C wiper, extends interrupted ground connected generator to the "+" ring wiper, and extends lower F to the "-" ring wiper. Direct ground on the C wiper causes the BCO of the called line to operate and clear the line of attachments. Relay D restores (following the resotration of relay E), and diverts part of the ringing current to the calling line as a ring-back indication.

(E) Ring-Back Tone: See previous discussion in Section 205(l). Note that the present circuit will afford no ring-back tone if the called line is open.

(F) Digit Absorption: (Operated; relays A, B, J, H, also VON). When the called party answers, the resulting direct current flow will energize lower F. Relay F operates, locks its upper winding to VON ground, opens the ringing circuit, extends release trunk ground to the C1 wiper and thence to relay L (Figure A) associated with the called line, and opens J. Relay L operates, extends the common "+" talk conductor to the "+" side of the called line, extends the common "-" talk conductor through upper L to the "-" side of the called line, and places direct ground on the C conductor associated with the called line. Relay J restores, removes ground from the C1 wiper, and closes the release magnet from ground on the release trunk. The release magnet operates to restore the Conference Call Connector to normal. The VON springs restore, open H and F, remove ground from the C wiper, and again direct the pulsing circuit to the vertical magnets. Relay H restores without effect. Relay F restores to close J. Relay J re-operates.

(G) Transmission: (Operated; relays A, B, J and L). The calling party informs the called party that there is to be a conference and to hold the connection. The circuit for talking is completed through condensers M and N, the back contacts of relay D and the upper winding of relay L. Relay A supplies talking battery to the calling party, and the impedance K supplies talking battery to the called party.

(H) Calling Other Parties On Progressive List: The calling party may now dial any other party on the progressive list. It will be remembered that relay D operates on each series of impulses. Its function is to open the talking common so that discharge currents from condensers M and N will not distrub parties already in on the conference. The calling party may continue to call the parties desired for conference without hanging up his receiver provided, (1) that all lines are free, and (2) that all parties answer. The two contingencies above mentioned will not interfere with the conference. The calling party merely restores his receiver momentarily, then dials whatever number is required to reach the Conference Call Connector, after which he proceeds as previously explained.

(I) Releasing: Any called party may retire from the conference at will. The restoration of any given receiver will open the upper winding of the associated relay L. Relay L restores to remove ground from the associated BCO, after which the line is at normal.

The complete switch train releases when the calling party restores his handset.

428 Trafficorder: Traffic studies were discussed in Section 173, with particular reference to the Multiple Pen Recorder. This device provides a permanent record in the form of a continuous line for each pen used.

The "Trafficorder," a more recent development, "scans or counts the trunk groups under observation, recording and printing at intervals of one minute the number of busy trunks or equipment in a group." In addition, one of these Trafficorders individually identifies each busy trunk, thus facilitating grading alterations.

For further discussion, see AETJ (Ostline) 4-48.

429 Trunking, Inter-Office: Inter-office trunking was discussed in Sections 113 and 213. See AETJ (Salvesen) 6-48 for article describing Interconnection Between Strowger and Ericsson Automatic Telephone Systems. Also see AETJ (Molnar) 4-48 for article covering Montevideo's Central Office Expansion Program. Further, see AETJ (Salvesen) 4-48 for article describing Interconnection Between Strowger and Rotary Equipment.

430 PABX: This general subject was discussed in Section 152. See AETJ (Jones) 4-48 for article describing Purdue University's P.A.B.X.

431 Rotary Line Switch: The rotary switch mechanism was discussed in Section 208. See AETJ (Huffman) 6-48 for an article describing a "high speed, heavy duty rotary switch having more positive action under severe operating conditions than switches heretofore available."

432 The Director: For prior discussion of the Director, see Sections 113(a) and 213(b). All that is said there is just as true today as it was when the sections were written - twenty-five years ago. The present day prospect of nation-wide toll dialing in the United States - for which the Director is ideally suited - makes an understanding of the Director both timely and advisable.

For further general discussion, see AETJ (Smith) 6-48. See also, AETJ (Plasmier) 4-48, "A Director Network in A Venezuelan Oil Field."

433 The Modern Director: The Director discussed in Section 113(a) and 213(b) was developed by Nelson and Richardson many years ago, (See AT 11-22). The modern Director (See A.E.Co. Bul. 1619), was developed by Ostline in 1946.

The basic theory as shown in Fig. 1, Section 213(b) is still sound. But the terminology has changed with the years, as indicated by the following "Director Functions," (1) Records or "registers" the number dialed by the subscriber; (2) Instantly analyzes the digits representing the area or exchange code, as soon as they have been received by the Director, and determines therefrom the best routing for the call; (3) "Translates" the area or exchange digits into a "directive," comprising the specific digits required for completing the desired connection over the required route to the terminating exchange. The numerical value of the directive is different from the dialed code digits; it may consist of the same number of digits, or a smaller or larger number of digits; (4) Sends out the pulses of the assigned "directive." Sending starts as soon as the Director has received the digits which indicate the area or exchange being called; the pulses transmitted operate the Strowger switches in exactly the same manner as the pulses from a subscriber's dial; (5) "Stores" the remainder of the called number (which represents the subscriber's terminal number as it is received from the calling dial) and sends these digits after the "directive," to control the numerical switches in the called exchange. Translation of this part of the number is not ordinarily required, but facilities for translation can be provided if required for any special services; (6) Releases itself from the connection as soon as the sending of the called number is completed; it is not used during the conversation.

The diagram below has been arranged to show how the Director functions in performing all of these operations in a typical toll and exchange network. The numbering plan in this toll network is designed to provide access to any telephone from any other telephone, by the toll operator dialing a number consisting of only ten digits. To make this possible, the entire network is divided into "toll areas," each having a "control center" through which all calls entering, leaving or passing through the area are switched. Each toll area has been assigned a three-digit number; each subscriber station has a standard seven-digit number (which is used when calling this station from any other telephone within this toll area). The combination of these numbers makes up a ten-digit number which distinguishes each telephone from any other telephone, anywhere in the entire toll or long distance network.

The diagram schematically represents ten exchanges, in seven toll areas. Toll lines between these exchanges are shown, and each is designated by the two-digit number which must be dialed to seize it and complete a connection through it.

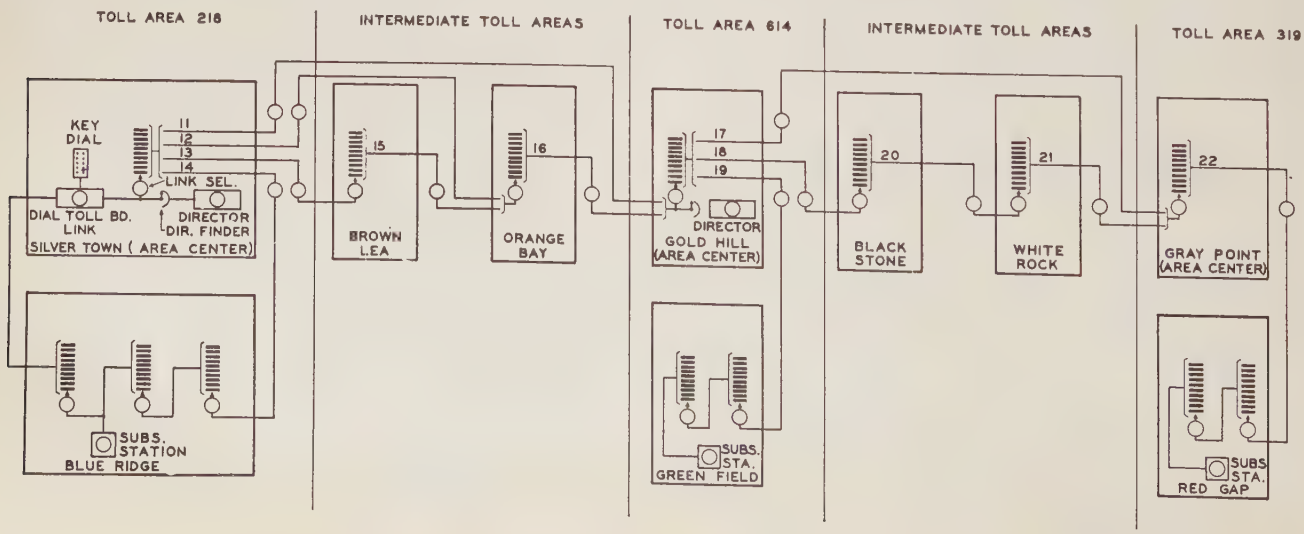
433(a) Translation: A connection may be completed from a subscriber station in Blue Ridge to a subscriber station in Green Field. This connection passes through Silver Town (area center for Blue Ridge) and Gold Hill (area center for Green Field).

The calling party at Blue Ridge gives the number of the desired station (GR5-1234) to the toll operator at Silver Town. She then "keys up" the number of the toll area in which Green Field is located (614), followed by the number of the called station. The Director proceeds to register the dialed digits, preparatory to translating them into the impulses required for extending the call.

As soon as it has received the 3-digit toll area code (614), the Director proceeds to set up the directive required to extend the call through Gold Hill to Green Field; when this exchange has been reached, the Director transmits the digits of the called station number.

If the called station is found to be busy, the Director instantly releases itself and the entire connection established, and transmits to the toll operator a "called-terminal busy" indication. If it is not busy, ringing starts and the completion of the call is indicated by a supervisory lamp in the toll link.

433(b) Alternative Routing: It is the "alternative routing feature" which makes the modern Director so superior to that of the older vintage.



(A) Secondary Routing: If the direct or preferred route between the calling and called toll areas is busy, the Director ascertains this fact and automatically sets up an alternative or secondary route, tandemed through one or more intermediate toll areas. This operation corresponds to that performed by a toll operator in calling a "route assignment" operator and then attempting to complete a connection over the secondary route assigned. The operation of the Director differs, however, in that it is practically instantaneous.

Assume the direct toll lines between Silver Town and Gold Hill are busy. The operator now sets up the desired number (614-GR5-1234) and the Director starts the call over the first or regular route. As soon as the Director finds the first route busy, however, it sets up an alternative directive, to switch the connection through Orange Bay and Gold Hill to Green Field. When connection to Green Field is completed, the Director transmits the digits of the called number, as before.

(B) Tertiary Routing: If the secondary route is found also to be blocked at any point, the Director automatically sets up a third alternative routing. It is only after this third route has been tried and found busy that the Director will release itself and the established connection, and transmit an "all lines busy" indication.

Assume that both the direct connection between Silver Town and Gold Hill, and the route to Orange Bay are busy. The operator sets up the desired number (614-GR5-1234), and the Director starts the call over the first route, then the second route. When this is found busy, the Director sets up a third directive which will extend the connection through Brown Lea, Orange Bay and Gold Hill to Green Field. This connection established, the Director transmits the digits of the called number.

If this third alternative routing is also busy, the Director, after trying all three routes and finding them blocked, releases itself and the connection which it has partially established, and transmits an "all-paths busy" indication to the toll operator.

(C) "Passing" Connections from Director to Director: For reasons of convenience and economy, the Director is ordinarily arranged to directly translate and issue complete directives only for calls within a reasonable distance; when a call is to be extended for a greater distance, the originating Director merely directs the connection to a Director in another toll center along the way, and then passes on to it the call number as originally set up. This second Director completes the call (or passes it on to still another Director, if necessary).

This may be demonstrated by the completion of a connection from Blue Ridge to Red Gap. The toll operator sets up the number of the toll area in which Red Gap is located (319), followed by the number of the called station (RE2-1234). As soon as the Director has received the 3-digit toll area code, it proceeds to set up a directive which contains the digits required to extend the call to Gold Hill. When this connection has been completed, the Director at Silver Town transmits to the Director at Gold Hill the entire 10-digit number originally keyed up by the Silver Town operator, and then releases itself from the connection. The Director at Gold Hill then takes over and completes the connection desired.

For further discussion see Automatic Electric Company Bulletin 302, 1619 and 2021.

434 Dialing Methods: Keeping pace with the development of new trunking methods, Strowger engineers have progressively developed various methods of dialing over inter-office trunks. Simplest of these is d-c "loop" pulsing - the dialing method used generally on subscriber lines. Modification of this method permit impulsing over trunks of up to 2000 ohms loop resistance; or, similar results may be secured through "simplex" dialing - impulsing through ground and the two line conductors in parallel.

When phantom trunks are used, "composite" dialing can be employed for dialing over the phantom and side circuits. If it is undesirable to "composite" such circuits, however, a-c dialing (at frequencies of about 60 cycles) or voice-frequency dialing (usually at 1000 cycles) can be employed. The latter, particularly, passes through voice frequency repeaters and carrier circuits without difficulty, and can thus be used over very long distances.

435 "Dry-Trunk" Repeater: In connecting telephone networks from magneto to central-battery operation, it was discovered many years ago that inter-office trunks paralleling power circuits became extremely noisy the moment they were connected to central-battery operation.

Seeking a solution to this problem, Strowger engineers developed the "dry-trunk" repeater and associated switching equipment, which permitted keeping the trunk "dry" (that is, carrying no direct current) except when actually dialing and signaling. When such a trunk was seized, current was placed on the trunk and interrupted in the usual manner. When the called party answered, direct current was instantly cut off the line, and transmission carried on on a "local-battery" basis - although central-battery telephones were used.

The "dry-trunk" repeater was first developed for use on loop dialing circuits. It was later adopted to the simplex and composite dialing arrangements known as "positive and negative" or "battery and ground" pulsing. These arrangements are now also in common use to overcome inductive and other noises on telephone transmission circuits.

436 Lock Pulsing: Conventional types of automatic telephone impulsing circuits assure dependable operation of switching equipment over a wide range of line conditions. On rural lines, however, extreme combinations of unfavorable factors (high loop resistance, heavily loaded lines, low leakage resistance) are often found, making conventional impulsing methods unsatisfactory. A solution is then found in the use of "lock pulsing".

The distinctive feature of this impulsing method is a "locking" circuit which assures that an impulse, once

initiated, will complete its function regardless of outside influences which would affect impulse length. It has thus become practical to serve rural lines having up to twenty stations, with line loop resistance as high as 1000 ohms, and leakage resistance as low as 5000 ohms, and with exchange voltage variations from 42 to 56 volts.

437 Automatic Switching of Toll Lines: This subject was covered briefly in Section 122. A recent article, "Equipment Facilities For Intertoll Dialing", AETJ (Kahn) 10-48, reads in part as follows: "Independent telephone companies are destined to play an important part in the nationwide operator toll dialing plan. This long range program contemplates that outward operators at an originating toll center will set up and extend toll calls on a nationwide basis directly to the called terminal; the assistance of any inward or through-switching operators will not be required if the call is destined for a subscriber in an automatic exchange". The article deals principally with equipment facilities for this service.

438 The Strowger Bank: Strowger bank capacities was rather fully discussed in Section 204. A recent article, "Strowger Bank Capacities - Their Effect on System Flexibility", AETJ (Molnar) 10-48, presents a summary of theory and practice extending from Strowger's original "collar box" switch to the 1948 version.

438(a) Strowger Mechanism: The Strowger Switch Mechanism was previously discussed in Sections 103 and 203. Molnar's article, mentioned above, has some very excellent cuts that show the evolution of the mechanism as well as the bank.

439 Trunking Within The Office: This general subject was discussed in Sections 112 and 212. A recent article, "Flexibilities In Trunking Arrangement From Strowger Selector Banks", will be found in AETJ (Salvesen) 10-48. The article discusses: (1) Superior efficiency of the large trunk group; (2) Methods of increasing efficiency of 10/10 selector outlets, (a) grading of bank contacts, (b) full secondary trunking, and (c) partial secondary trunking; (3) Savings effected by secondary trunking; (4) The 10/20 Selector; (5) The 600-point bank; and (6) Flexibility of Strowger apparatus.

440 Prognostication: At the time this section is written, it appears likely that AETJ 1-49 will contain five very interesting articles: (1) Automatic Pulsing on Carrier Current Telephone Channels - Molnar; (2) Use of Switching Selector Repeaters In Multi-Office Networks - Salvesen; (3) Fort Wayne's Mobile Radio System - Dimmer; (4) Intercepting Service as Applied to Automatic Systems - Diezel; and (5) Super-Imposed Ringing - Popple.

# APPENDIX "G"

# TYPICAL ADJUSTMENTS

(Courtesy of Automatic Electric Company)


| Adjustment | | | Page No. |
|---|---|---|---|
| A-000 | Sequence of Strowger Switch Inspection | | G-1 |
| A-100 | General Requirements | | G-6 |
| A-101 | Shelf Jacks, Covers, Bases and Busy Keys | | G-7 |
| A-110 | Horizontal Relays, Single Contact (See A-173) | | G-9 |
| A-120 | Off-Normal Spring Assemblies | (S.S.W.M.) | G-15 |
| A-121 | Shaft Spring Assemblies | (S.S.W.M.) | G-16 |
| A-122 | Cam Spring Assemblies | (S.S.W.M.) | G-16 |
| A-130 | Vertical Mechanism | (S.S.W.M.) | G-17 |
| A-131 | Switch Dogs | (S.S.W.M.) | G-18 |
| A-132 | Rotary Mechanism | (S.S.W.M.) | G-19 |
| A-133 | Release Mechanism and Springs | (S.S.W.M.) | G-20 |
| A-135 | Shafts, Wipers and Banks | (S.S.W.M.) | G-21 |
| A-136 | Minor Switch | | G-23 |
| A-173 | Horizontal Relays, Twin Contact, and Type "Z" (See A-110) | | G-25 |
| A-805 | Dial | | G-28 |


CAUTION:

The Adjustments shown herein should not be considered authoritative or official. They are a streamlined version worked up for one particular type of installation, and do not necessarily have universal application.

They are presented merely as educational matter for the thousands of readers who do not have access to official Strowger literature.

# INDEX - MAKE USE OF IT

## APPENDIX "G"
## APPENDIX "H"


"AH" Sheets, G-31, G-44
"MD" Drawings, G-31, G-45

AIR GAP
- Heelpiece, G-10
- Residual, G-9

Busy Key, G-39

Condensers, G-34
Cradle Switch, G-33

DIAL
- Adjustment, G-26
- Circuit, G-34
- Mechanism, G-32

Drawings, G-31

Gauging, Spring, G-10, G-41

Handset, G-32

Induction Coil, G-34

JACKS
- Switch, G-39
- Test, G-39

Margining, Spring, G-11, G-41

MINOR SWITCH
- Adjustment, G-23
- Mechanism, G-39

Receiver Unit, G-32

RELAY
- Adjustment, G-9, G-25, G-44
- Double Armature, G-43
- Mechanism, G-40
- Mounting, G-39
- Short Lever, G-43
- Slow Acting, G-42
- Twin-Contact, G-25, G-43
- Two-Step, G-43
- Type "Z", G-43

RINGER
- Circuit, G-34
- Mechanism, G-33

SPRINGS
- Adjustment, G-41
- Assembly, G-41
- Cam, G-16
- Gauging, G-10, G-41
- Interrupter, G-39
- Margining, G-11, G-41
- Off-Normal, G-15, G-38
- Release-Signal, G-39
- Shaft, G-16
- Tension, G-12

STROWGER SWITCH
- Adjustment, G-1 to G-22
- Inspection, G-1
- Mechanism, G-36

System, Functions of, G-36

TELEPHONE
- Circuit, G-34
- Instrument, G-32
- System, G-31, G-36

Transmission Circuit, G-34
Transmitter Unit, G-32

Varying, G-5

# ADJUSTMENT A-000

## SEQUENCE OF STROWGER SWITCH INSPECTION

1. INTRODUCTION

Adjustment A-000 has been prepared in order that there may be one complete guide to the inspection and adjustment of the Strowger Switch Mechanism.

2. SEQUENCE OF STROWGER SWITCH INSPECTION

a. Check for loose screws, damaged parts, excessive wear.

b. Check the shaft spring tension according to A-121, B1 and B2 (refer to the Relay Adjustment Sheet for the switch being tested; certain types of switches have special requirements specified thereon).

c. Check the vertical armature for correct play and spring tension according to A-130, B1 and B4. (See Section 4, "Varying".)

d. Check the rotary armature for correct play and spring tension according to A-132, B1 and B4 (refer to the Relay Adjustment Sheet for the switch being tested; certain types of switches have special requirements specified thereon). (See Section 4, "Varying".)

e. Check the play of the double dog according to A-131, B1.

f. Check the double dog spring tension and alignment according to A-131, B5 and B6 (refer to the Relay Adjustment Sheet for the switch being tested; certain types of switches have special requirements specified thereon).

g. Check the alignment of the rotary dog according to A-131, B7.

h. Check the alignment of the rotary pawl according to A-132, B3 and C7.

i. First check the adjustment of the rotary pawl guide screw according to A-132, C2. Second, check the setting of the normal pin according to A-132, C4.

j. Check the adjustment of the rotary armature back stop according to A-132, C5.

k. Check the adjustment of the release link according to A-133, B1.

l. Check the adjustment of the vertical off-normal springs according to A-120, B1 to B9, inclusive.

m. Check the tension of the rotary interrupter springs, if used, according to A-132, D2 (refer to the Relay Adjustment Sheet for the switch being tested. Certain types of switches have special requirements specified thereon).

n. Check the adjustment of the cam springs, if used according to A-122, B1 to C4 inclusive (refer to the Relay Adjustment Sheet for the Switch being tested; certain types of switches have special requirements specified thereon, also, certain types of switches are adjusted in accordance with A-120 instead of A-122).

o. Check the adjustment of the release armature pin according to A-133, C1 and C2.

p. Check the stroke of the release armature (which is controlled by the screw at the upper end of the release armature) according to A-133, C3.

q. Check the adjustment of the release contact springs (release signal), if used, according to A-133, E1 to E3, inclusive.

r. Check the vertical pawl alignment according to A-130, C4.

s. Check the vertical magnet adjustments according to A-130, B2 and B3.

t. Check the rotary magnet adjustments according to A-132, B1 and B2.

u. Check the rotary pawl front stop adjustment according to A-132, C3.

v. Check the gauging of the rotary interrupter springs, if used, according to A-132, D1 (refer to the Relay Adjustment Sheet for the switch being tested; certain types of switches have special requirements specified thereon).

w. Check the adjustment of the vertical dog according to A-131, B3.

x. Check the adjustment of the stationary dog according to A-131, C2 and C3.

y. Check the adjustment of the vertical pawl guide according to A-130, C2 and C3.

z. Check the position of the cam, if used, to confirm that it operates the cam springs according to the circuit.

aa. Check the adjustment of the vertical interrupter springs, if used, according to A-130, D1, D2, E1, and E2 (refer to the Relay Adjustment Sheet for the switch being tested; certain types of switches have special requirements specified thereon).

3. NOTES ON STROWGER SWITCH MECHANISM

See "Plate A", "Plate B", and Fig. 2, page 35, for aid in identifying the various parts of the Strowger Switch Mechanism.

3.1 Rotary Adjustments (See Figs 2, 3 and 4)

a. Rotary Pawl Guide (Requirement A-132, C2)

With the shaft up one step and in one step, see that the rotary pawl guide is set so that the rotary pawl either strikes squarely at the base of the second tooth or slides slightly on the third tooth to the base of the second. Rotary pawl must not strike high on the second tooth and slide down to its base. The rotary teeth are numbered in the order engaged by the pawl as the shaft rotates. Rotate the shaft to successive steps and see that the rotary pawl strikes within the same limits on the succeeding teeth.

b. Normal Pin (Requirement A-132, C4)

With the shaft up one step, see that the normal pin is set so that when the rotary armature is operated and the pawl strikes in the same relative position as on the succeeding teeth. If the pawl strikes high (on the first tooth) shift the normal pin to the left. If the pawl strikes low and slides too far on the second tooth, shift the normal pin to the right.

c. Stationary Dog and Wipers (Requirements A-131, C1, A-135, B6, B7 and B9)

If it has been necessary to move the normal pin, inspect the stationary dog to see if it clears the shaft teeth during the vertical movement. Also inspect the wipers to see that they do not catch on the insulators during the vertical movement, and that they are properly positioned on the bank contacts during the rotary movement of the shaft.

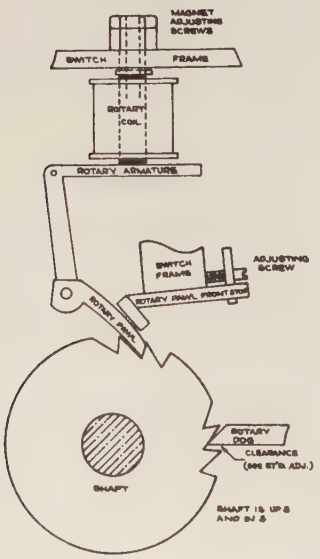



FIG. 2 ADJUSTING ROTARY MECHANISM

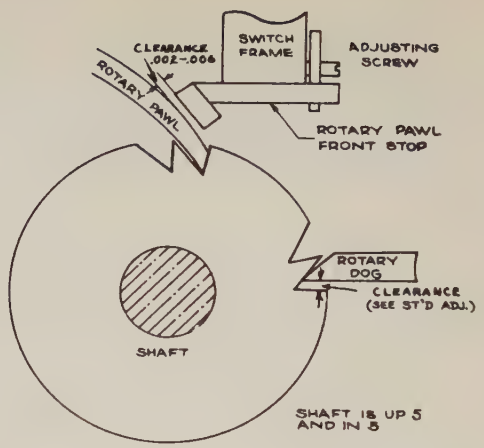



FIG. 3 SETTING PAWL GUIDE

d. Rotary Armature and Rotary Magnets (Requirements A-132, B1, B2, and C5)

Make sure that the front pawl stop is set so that the rotary pawl will not strike the stop while the rotary magnet adjustment is being made. Step the shaft up to the fifth or sixth level in making this test, and then check the space between each rotary tooth and the rotary dog while the rotary magnets are energized. Draw the rotary magnet away from the armature to increase the space between the teeth and the dog and move the magnet toward the armature to decrease the space. Tighten the lock nut on the adjustment bushings if the magnet has been moved before measuring the space.

After setting the space on the 5th or 6th level, test the space between each tooth and the dog on the 1st and on the 10th levels. The rotary dog must not be bent to set this space. Make sure that the armature strikes both cores squarely and at the same time. With this adjustment, the rotary dog will be sure to drop over one tooth after each rotary impulse.

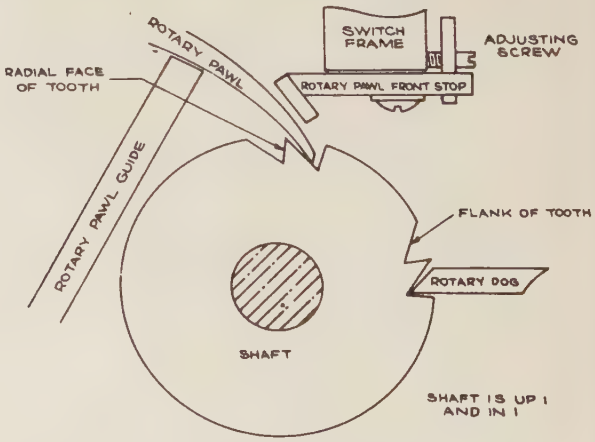



FIG. 4 SETTING PAWL & DOG

e. Front Stop Adjustment (Requirement A-132, C3)

With the rotary magnet energized, see that the pawl has proper clearance between the stop and the rotary hub (the width of the standard thickness gauges makes it difficult to employ them in checking this requirement, and particular care should be exercised on that account). If a considerable number of switches are to be checked, it is suggested that split thickness gauges be used, (if they can be obtained). The pawl must not be wedged between the shaft hub and stop so that there is not rotary play in the shaft. Test the rotary play in the shaft with the rotary magnet energized by moving the normal pin back and forth with one finger placed on the end of the normal pin. If the stop is correctly adjusted, an increase in space between the rotary dog and tooth will be noticed during the test.

This adjustment will prevent the rotary dog from dropping over more than one tooth after each impulse. It also causes the wipers to stop directly on the proper bank contact instead of allowing them to be momentarily carried off the contact by the momentum of the shaft as they would be if there were too much rotary play in the shaft.

f. Interrupter Springs (Requirement A-100, D1 and D2)

See that the interrupter springs are approximately parallel to the switch frame and that the contact points are properly aligned.

g. Tension and Gauging (Requirement A-132, D1 and D2)

The gauging and tension of the interrupter springs should be inspected to see that they agree with the applicable Adjustment requirements or any special requirements which may be specified on the Relay Adjustment Sheet for the switch being tested.

h. Rotary Armature Spring (Requirement A-132, B4)

The tension of the rotary armature retractile spring is checked by determining that the rotary action is the best possible during varying in the case of connectors or during automatic rotary in the case of selectors or finders. Any special requirements, on the Relay Adjustment Sheet for the switch being tested should be noted. (See Section 4, "Varying.")

i. Shaft Spring (Requirement A-121, B1)

Inspect the tension of the shaft spring in accordance with applicable Adjustment requirements or any special requirements which may be specified on the Relay Adjustment Sheet for the switch being tested. Rotate the shaft by hand on the 1st and 10th levels to test for shaft spring bind. Check that the shaft is positively restored to normal when released.

j. Rotary Speed Adjustment

If the shaft does not rotate at the proper speed, check the following adjustments:

1st—Margining and gauging of the interrupter relay.
2nd—Interrupter spring break (check with the rotary magnet energized).
3rd—Amount of tension in the rotary armature spring (vary until best results are obtained).

k. Cam Springs (Requirements A-122, B1 to B6 and C1 to C4)

Inspect the adjustment of the cam springs according to the applicable Adjustment requirements or any special requirements which may be specified on the Relay Adjustment Sheet for the switch being tested. Check the distance between the bottom of the rotary ratchet and the cam spring assembly.

If the Relay Adjustment Sheet calls for A-120, it should be followed in lieu of A-122.

3.2 Stationary and Double Dog Adjustment (See Figs. 5, 6, 7 and 8)

a. Double Dog Spring (Requirement A-131, B5 and B6)

The tension and alignment of the double dog spring should be inspected according to the applicable Adjustment requirements or any special requirements which may be specified on the Relay Adjustment Sheet for the switch being tested.

b. Vertical Hub Nicking (Requirement A-131, B2)

The vertical dog must ride directly in the nicking of the vertical hub during vertical motion.

c. Space between Vertical Dog and Shaft (Requirement A-131, B4)

Test for space between vertical dog and shaft when up one by inserting the proper thickness gauge between the top of vertical dog and the under surface of the vertical teeth. Try on all teeth except the tenth. To obtain the above space, use the dog bender and bend the vertical dog, while holding the whole assembly with flat nose pliers. The rotary dog must never be bent during the vertical dog adjustment or any other adjustments.

d. Drop in Shaft (Requirement A-131, B3)

When the vertical magnet is energized as in testing for "play-in-shaft": (a) The shaft must not drop perceptibly on all levels (but may drop perceptibly on some levels) when the magnets are de-energized. (b) The vertical dog should not rub on the under surface of the vertical teeth to an appreciable extent. Try both of these tests on all teeth.

e. Space Between Stationary Dog and Vertical Teeth (Requirement A-131, C3)

Test for space between stationary dog and vertical teeth by raising the shaft, when cut in, and inserting the proper thickness gauge between the bottom surface of teeth and the stationary dog. This adjustment prevents the catching of wipers on bank insulators when the shaft is released from the eleventh rotary

position. The wipers must not be raised enough to allow them to catch on the bank insulators or contacts during this test.

3.3 Off-Normal Spring Adjustment

Inspect Off-Normal Spring Alignment (Requirement A-120, B1)

The alignment of the off-normal spring assembly should be inspected according to the requirements of the Adjustment.

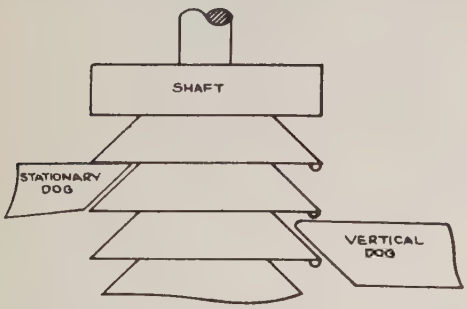



FIG. 5 SETTING STATIONARY DOG

Inspect Off-Normal Lever Adjustment (Requirement A-120, B2 to B5, Inclusive)

A little play is essential in off-normal lever bearings. The gauging of the off-normal spring assembly should be inspected according to the applicable Adjustment requirements.

Inspect Off-Normal Spring Tension (Requirement A-120, B6, B7, and B8)

Inspect tension of the off-normal spring in accordance with the requirements of the Adjustment.

3.4 Release Adjustment (Requirements A-133, All Sections)

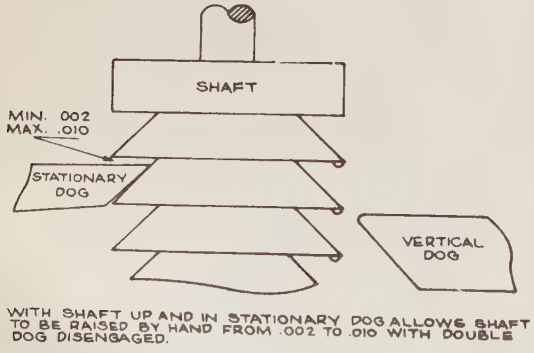



FIG. 6 SETTING STATIONARY DOG

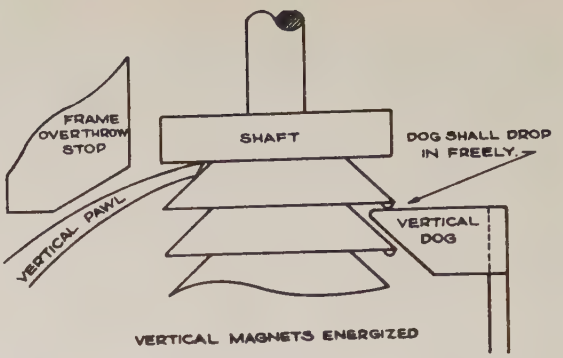



FIG. 7 SETTING VERTICAL DOG

Check release adjustment of switches to insure that this adjustment conforms with the requirements of the Adjustment.

3.5 Vertical Adjustment (See Figs. 9 and 10)

a. Inspection of Vertical Pawl Guide Adjustment (Requirement A-130, C2 and C3)

Check the adjustment of the vertical pawl guide (lower portion of stationary dog bracket) to see that the vertical pawl clears the top of the rotary hub with the shaft up 10, the pawl clears the vertical teeth as the shaft releases, and that the vertical pawl finger clears the vertical pawl guide slightly before the shaft starts to move vertically under the control of the vertical armature. This adjustment may be checked by raising and lowering the shaft by hand, at the same time noting the position of the pawl to the shaft.

b. Method of Shifting Vertical Magnets

If current is not used, as in the case of replacing a defective magnet, hold the switch in such a position that space, if any, can be seen between the vertical magnet and vertical armature when the vertical pawl is pressed upward lightly against the frame. If any space is seen between either magnet and the armature, move the vertical magnet downward by shifting the

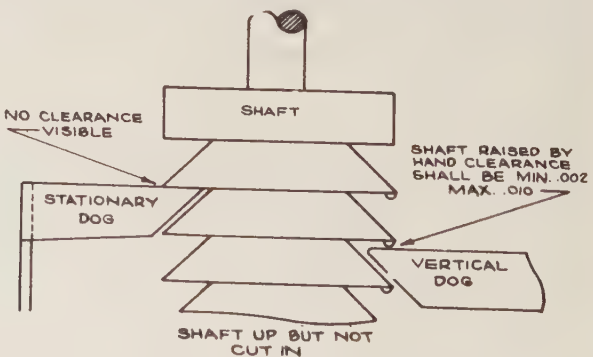



FIG. 8 SETTING STATIONARY & VERTICAL DOG

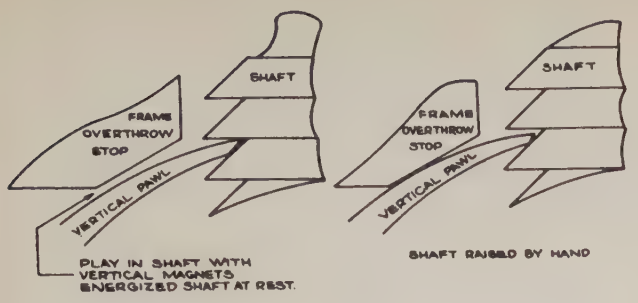



FIG. 9 ADJUSTING VERTICAL PAWL & STOP

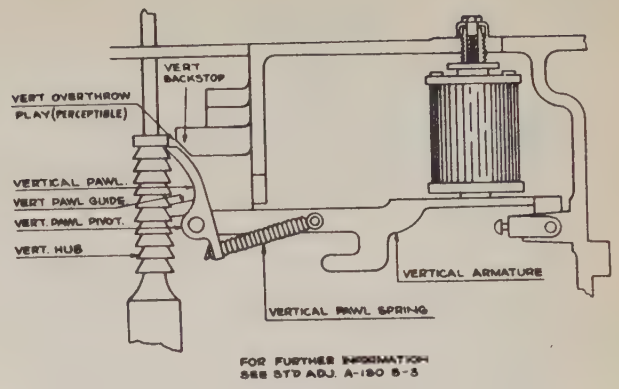



FIG. 10 ADJUSTING VERTICAL MECHANISM

vertical magnet adjustment bushings after loosening the assembly locking screws.

To move the vertical magnet downward turn the adjusting bushings in a clockwise direction. To raise the vertical magnet turn the adjusting bushings in a counter-clockwise direction. Always tighten the locking screws after shifting the adjusting bushings.

c. Vertical Play in the Shaft (Requirement A-130, B2 and B3)

To test for play in shaft: (1st) Operate the vertical armature by holding the off-normal springs deflected with the thumb on the left hand and mechanically operating the "B," or release, relay armature with the first finger of the same hand. This electrically energizes the vertical magnets. With the "B" relay armature held operated, tap the armature of the "A" relay which raises the shaft to any level desired. (2nd) After the shaft responds, lift it by slight pressure on the bottom of the rotary hub and notice the amount of vertical play. The pressure used should be but little more than necessary to lift the normal weight of the shaft. This method is important to insure uniformity and must be adhered to. The play should not exceed the amount specified in the appropriate Adjustment. Play in shaft is normally governed by raising or lowering vertical magnets.

d. Kick of Armature

If the requirements for magnet alignment and vertical play mentioned in the preceding paragraph (B2 and B3 of A-130) have been met, there will be no "kick of armature." To illustrate "kick of armature" hold the vertical armature against the magnet by hand pressure and energize the magnet. A movement or springing of the armature will be noticed if the magnet is too high, or out of line. It is this spring and subsequent return which is termed, "kick of armature."

To test for kick of armature: (1st) Operate the vertical armature as in "play in shaft" described above. (2nd) When the vertical armature responds, hold the armature against the vertical magnet with the first or second finger of the right hand while pressing the thumb of the same hand against the top of the switch frame. By holding the armature in this manner and raising the shaft as described above by tapping the "A" relay with the "B" energized, the adjuster can feel the armature "kick" when either one or both of the vertical magnets are too high.

e. Vertical Armature Spring (Requirement A-130, B4)

The tension of the vertical armature retractile spring is checked by determining that the vertical action is the best possible during varying in the case of connectors or selectors, or during the automatic vertical action in the case of finders. (See Section 4, "Varying.")

f. Vertical Interrupter Springs (Requirements A-130, D1, D2, E1, and E2)

Inspect the adjustment of the vertical interrupter springs according to the applicable Adjustment requirements or any special requirements which may be specified on the Relay Adjustment Sheet for the switch being tested.

4. VARYING

"Varying" is a test (and if necessary a readjustment) of armature retractile spring tension to insure satisfactory operation, at maximum impulsing speed, on impulses from lines of the limiting series and shunt resistances. Minor switches as well as Strowger switches should be subjected to this test. The varying test also detects any unsatisfactory adjustment of the impulsing relay, or the slow-to-release relays, which must function correctly during impulsing.

Thus "varying" is a test to ensure that a switch will operate from a dial over varying line conditions. The varying operation is used to test the switch to make certain that its operating margin is such that it will operate satisfactorily over lines of maximum loop resistance and minimum allowable leak resistance.

# ADJUSTMENT A-100
# FOR
# GENERAL REQUIREMENTS

A. LOOSE PARTS

1. Unless otherwise specified, all screws and nuts should be tight.

2. All coils, relays, and other parts should be securely mounted or assembled.

B. NOT APPLICABLE.

C. NOT APPLICABLE.

D. SPRINGS, CONTACTS AND BUSHING

1. Spring Assemblies should have springs, contacts and bushings well aligned.

2. The following gradual bow in the free length of any spring is permissible but there shall be no sharp bends or kinks in the springs due to adjustment.

   Readj.—Maximum .020"
   Test —Maximum .020"

   NOTE: In the case of horizontal relay twin contact springs, armature springs may also be bowed from armature or spring bushing to contact end of spring when operated, or at normal, provided the above requirement is met when the springs are not making contact.

3. In spring pile-ups having more than one back contact, an effort shall be made to distribute uniformly the pressure of the lever springs against the back springs. In spring pile-ups having no back contacts, an effort shall be made to distribute the tensions uniformly among the lever springs, unless otherwise specified.

   NOTE: This requirement may be considered to have been met if each armature spring rests against the armature bushing, associated back contact or preceding armature spring, as the case may be, when the pressure of the succeeding spring or springs is relieved or if at least a perceptible follow of each back contact spring occurs upon manual operation of the relay. The follow may be gauged by eye.

4. Contacts should not be out of alignment with respect to each other more than ⅓ of their diameter measured at the base of the contact points as gauged by eye.

5. Bushings shall be approximately in alignment with the center of the springs against which they strike, as gauged by eye. This requirement shall not apply to the off-normal spring assembly lever bushing.

E. COILS

1. Coils should measure within plus or minus 5 per cent of their specified resistance unless otherwise specified.

   NOTE: The resistance values of the windings are based upon a normal temperature of 68°F., and unless otherwise specified, the resistances should be measured at this temperature or temperature correction values shall be applied to compensate for other temperatures.

2. Coil covers should fit neatly and securely on coils.

F. RESIDUALS

1. Stationary residuals should fit tightly to core ends.

2. Adjustable residual screws should be adjusted as specified on the relay adjustment sheet.

G. SCREW ADJUSTMENTS

1. All adjusting screws, except as noted in G-2 and G-3 below, as finally adjusted, should have unused threads available for future adjustment.

2. All adjusting screws on Strowger switches (except as noted in G-3 below), as finally adjusted, should have at least two unused threads available for future adjustment.

   NOTE: In the case of the rotary pawl guide screw, which is a slotted headless screw, the the two unused threads should be considered from the end of the screw and not from the bottom of the slot.

3. Rotary and vertical magnet screws on Strowger switches, as finally adjusted, should have a minimum of .020" available for future adjustment in either direction.

H. CLEANLINESS

1. Equipment should be free from grease, grit or any other foreign matter which is likely to impair operation.

# ADJUSTMENT A-101
# FOR
# STROWGER SWITCH SHELF JACKS, BASES, COVERS, TEST JACKS AND BUSY KEYS

## I. INTRODUCTION

This adjustment pertains to the following portions of the apparatus making up a Strowger Switch Assembly, Shelf Jacks, Bases, Covers, Test Jacks and Busy Keys.

Adjustments A-100, A-120, A-121, A-122, A-130, A-131, A-132, A-133, A-135, and A-136, together with this adjustment complete the requirements for Strowger Switch mechanisms.

## II. ROUTINE INSPECTION

Shelf Jacks: Very little readjustment will be necessary for shelf jacks. To be certain of proper tension of the jack springs against the switch jacks, the requirements III-B-1 should be checked. If jack springs are readjusted to meet this requirement, they should be inspected to see that they also meet the remaining requirements, Sections III-B-2 & 3.

When adjacent jack springs are required to make contact when a switch is not in the jack, they should be inspected and adjusted if necessary according to section III-B-4.

Bases: The bases will, in general, not require any adjustment after leaving the factory. Should they become loose in the shelf, however, the adjustment in Section III-C-1 should be made.

Covers: The covers are properly fitted at the factory and will not require additional adjustment. When removing and replacing a cover, care should be taken so that it does not strike the switch or associated relays.

Test Jacks: The test jacks should be checked for proper spring tensions and ease of insertion of the test plugs, Section III-E.

Busy Keys: In general, because of the small amount of use they receive, busy key springs will not require readjustment. If they should, the cam spring should be tensioned to give the required follow of the break contact spring and the make spring then adjusted to secure proper make contact follow; care being taken to see that the break contacts break before the make contacts make. Section III-F.

## III. SPECIFIC REQUIREMENTS

### A. General

1. The parts shall meet the general requirements specified in A-100 which are applicable.

### B. Shelf Jacks

1. When the switch is removed from the jack, the clearance between each pair of jack springs should be minimum .015", maximum .025", gauged at the closest point between the available contacting surfaces.

2. The springs of a pair should be approximately parallel, except as specified in paragraph 4, below.

3. There shall be perceptible clearance between adjacent springs not in the same pair, when a switch jack is properly inserted into the shelf jack.

4. When adjacent jack springs are required to make contact, when a switch is not in the jack, the springs required to make contact shall be tensioned against each other so that when the pressure of one spring of the pair is removed, its mate will follow approximately 1/32".

### C. Bases

1. The angles of the relay or switch bases, which form the lower part of the upper mounting slots, and the extreme lower angles of the rear of the base, should be bent out to hold the base approximately centered in the shelf mounting space.

2. The location of the relay insulator, in respect to the mounting plate, should be such that the coil terminal clearance holes are approximately concentric with the holes in the mounting plate, as judged visually.

### D. Covers

1. Each front switch cover should rest on the top surface of the mounting plate and on the lower cover plate. The space between the front cover and the lower cover plate shall not be greater than 1/16", at any point. The cover should also fit snugly on the sides of the mounting plate.

2. When a minor switch is mounted on the mounting plate, its tenth bank contact terminals shall be bent apart, so that they will not make contact with this cover.

3. The cover should not interfere with any of the apparatus on the mounting plate.

4. Not Applicable.

5. The top edge of the back cover should be securely held against the mounting plate by the clamping screw; its lower edge being held by the bayonet slots in the mounting plate. When the apparatus units are mounted on the mounting plate, the back cover shall not make contact with any of their terminals.

E. Test Jacks

1. The spring tips of tests jacks should be bent together so that the test plug may readily enter the jack when the test plug is held at approximately a 10° angle above the horizontal.

2. With the test plug in position, each jack spring shall make contact with its corresponding test plug member, and adjacent pairs shall have a clearance of minimum 1/32".

3. Not Applicable.

F. Busy Keys

1. The cam spring shall contact the cam the full width of the cam surface.

2. Make and breaks springs shall have .015" minimum follow as judged visually.
NOTE: On break-make spring combinations, the break contacts shall open before the make contacts close, as judged visually.

3. With the key at normal, and one side of the formed end of the cam spring resting against the cam slot, there should be .005" minimum, .020" maximum clearance between the other side of the formed end of the cam spring and the cam slot.

NOTE: The springs may be bent to meet this adjustment.

4. There should be minimum .010" clearance between all springs and the flat side of the frame, and last spring of the pile-up and the end of the frame.

5. There should be minimum perceptible clearance between the cam spring, and the bushing of the second moving spring.

# ADJUSTMENT A-110 FOR HORIZONTAL RELAYS, SHORT LEVER RELAYS, AND TYPE #28 "Z" RELAYS

## 1. FOREWORD

### 1.1 Introduction

The horizontal, Type #28 "Z", and short lever armature relays, consist of the following parts: coil assembly, heelpiece, armature assembly, and spring assembly or assemblies.

Various terms used in the requirements throughout this Adjustment will have the following meaning:

a. "Spring Combination" is the entire spring assembly of either a single or double armature relay.

b. "Spring Pile-up" is an assembly of all the springs operated by one armature arm.

c. "Contact Springs" are the individual springs of a spring pile-up or a spring combination.

d. "Two-step Operation Relays" are relays having separate electrical requirements for one or more pairs of contact springs.

On the horizontal and Type #28 "Z" relays, the lever ratio between residual screw and armature buffer is about 2.25 to 1, and on the short lever armature relays this ratio is about 1 to 1.

The assembly screws are tightened after the insulators have been heated and while the pile-ups are under pressure. Any changes in spring combinations should preferably, therefore, be made at the factory.

### 1.2 Notes on Relay Inspection and Adjustment

#### 1.21 General

The foremost rule of relay maintenance is do not readjust a relay until it is certain that the relay is out of its allowable operating range, as determined by the five-step inspection routine outlined below:

(1) CHECK GENERAL REQUIREMENTS. Check for general mechanical defects such as loose parts, bent springs, contacts out of alignment, etc., in accordance with Adjustments.

(2) CHECK RESIDUAL AIR GAP. See the Relay Adjustment Sheet ("AH" series) for nominal values and refer to applicable Adjustment ("A" Series) for tolerances allowed.

(3) CHECK HEELPIECE AIR GAP. See Standard Adjustment ("A" series) for limits and also note whether special requirements are specified in the Relay Adjustment Sheet ("AH" series).

(4) CHECK SPRING GAUGING. See the Relay Adjustment Sheet ("AH" series) of nominal gauging values and refer to applicable Adjustments ("A" Series) for procedure, tolerances, etc. Check armature stroke and armature back-stop setting.

(5) CHECK MARGINING. See applicable Adjustments ("A" Series) for procedure and refer to Relay Adjustment Sheet ("AH" series) for resistance or current values and testing instructions. These electrical requirements will usually be met without readjustment, however, if it is necessary to change spring tensions to meet margining values, the spring gauging must be rechecked.

For a general description and diagrams of relays see Section 10, page G-40, entitled "Mechanics of the Relay". Note particularly Sub-section 10.5 entitled "Spring Adjustments", page G-41.

Information regarding relays and their adjustment is divided into two classes: (1) specific requirements for each relay, and (2) general requirements for all relays of a class.

Specific requirements for each relay are given on the Relay Adjustment Sheets ("AH" series) which cover each particular relay in a given circuit. Such a sheet usually bears the same number as the circuit prefixed by "AH." Information found on such a sheet includes residual values, schematic diagram of the spring pile-up with gauging values, resistance and current values for margining, testing instructions, and list of applicable Adjustments. Current values are used only in conjunction with current-flow type test sets.

The "general requirements" are given in the applicable Adjustments ("A" Series). These drawings include information on adjusting procedures, tolerances, mechanical requirements, etc. They should be studied carefully before any adjustments are attempted. For applicable Adjustments ("A" Series), refer to first page of the Relay Adjustment covering the circuit used.

#### 1.22 "Residual" Air Gap

The "residual" air gap is the space remaining between the armature and the magnet core when the relay has operated fully. This space is adjusted by means of the brass screw in the center of the armature which screw projects toward the core such that it strikes the core before the armature does. If the armature were allowed to strike squarely upon the core, residual magnetism remaining in the core might cause the relay to remain operated after the magnet circuit is opened. The residual gap is checked by inserting a gauge between the armature and the core with the residual screw projecting through the hole in the gauge. Operate relay electrically as described

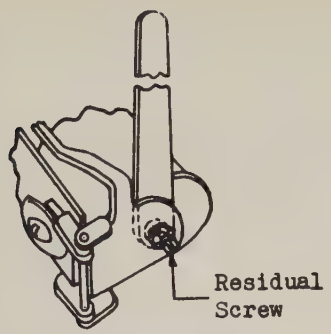



FIG. 1 PROCEDURE FOR CHECKING RESIDUAL GAP

on the appropriate "A" drawing. "Feel" of the gauge will tell if the gap is correct. Refer to the specific "AH" drawing covering the relays of the circuit in hand for the correct residual value. See applicable Adjustments under the heading of "Residuals" for tolerances in Adjustment.

1.23 Heelpiece "Air Gap"

The heelpiece "air gap," frequently called the "air line," is the space provided between the armature and the heelpiece when the armature is in its operated position. This space must be sufficiently large so that the armature will not bind and yet be as small as possible in order to offer a minimum resistance to the magnetic lines of force. These magnetic lines follow a complete path from the front of the core through the armature, heelpiece, and thence to the rear of the core. The more of this path which is in soft iron, the more powerful the relay. To adjust the "Air Gap," loosen the armature-bearing-yoke-clamp screw, insert the correct gauge between the armature and the heelpiece, operate armature, and tighten clamp screw. For details refer to the appropriate "A" drawing.

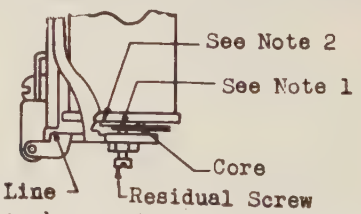
1.24 Spring Gauging

Spring gauging covers the adjustment of the armature stroke and of the relay springs. By means of gauging, the positions of the make (front) and break (back) springs relative to the armature (movable) springs are determined, and hence, the sequence with which armature springs make or break contact with the associated springs is established. However, before proceeding with the actual gauging, the springs must be checked for straightness and other characteristics as described in the appropriate Adjustments (Generally A-100); also the armature springs must have approximately the correct tension. If the relay is completely out of adjustment, tension must be applied as described in Section 1.26. When necessary, which is seldom, and prior to any attempt at gauging, the armature lever is adjusted. Armature bender 14768 is used to bend the armature to such a position that it will operate the springs when they are properly adjusted. Since the applicable Adjustments ("A" series) require that the springs appear parallel to the heelpiece, the lever must be bent so as to operate the first break contact when the appropriate gauge is positioned between the armature and the core. A diagram of each relay spring assembly is included on the Relay Adjustment ("AH") Sheets. Gauging values are shown between each pair of springs. If the contacts are shown closed (relay not operated), they will be called break contacts, and the gauging value between their springs indicates that the contacts should just break (open) when the armature is the specified distance from the core. Similarly, the value given between two open contacts, called make contacts, indicates that the contacts should just make when a gauge of the specified thickness is positioned between the armature and the coil core with the relay electrically operated. Thus in "A" of Figure 2A, a single break contact is shown with the value .006 between the break and armature springs. This indicates that with a .006 inch gauge between the armature and the core, the break contacts should just break, as judged visually. The applicable Adjustments specify the tolerances allowed.

In "C" of Fig. 2A, a value of .010 is specified between the break and armature springs and .006 between the make and armature springs. This indicates that the break contacts are to open when the relay armature is .010" from the core (.010 gauge between armature and core). The make contact will just close when the armature has further operated to within .006" of the core.

Continued operation of the armature causes the make contact spring to deflect under pressure of the armature spring. Contact pressure is, thus, built up insuring adequate electrical closure of the circuit. Notice that the armature spring leaves the break contact before touching the make contact, thus avoiding any possibility of interconnecting two circuits.

When the contact nearest the heelpiece is a break contact (A, C, E, F of Fig. 2A), the armature back stop does not need adjustment other than to see that




NOTE 1 If relay has .0015" residual (or more) of either adjustable or fixed type with dia. considerably smaller than the core extend gauge only past edge of residual screw or disk.

NOTE 2 If rly. has zero residual, or residual cap, or fixed residual not appreciably smaller in dia. than the core, cover end of core with gauge.

FIG. 2 PROCEDURE FOR CHECKING ARMATURE STROKE AND SPRING GAUGING

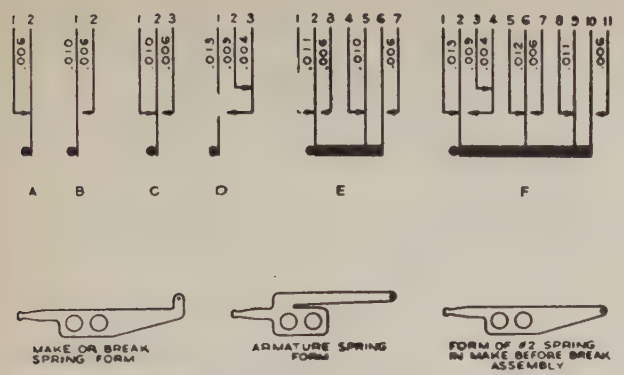



FIG. 2A TYPES OF RELAY SPRING ASSEMBLIES

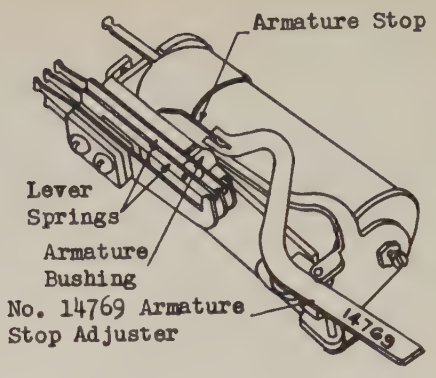



FIG. 4 ADJUSTMENT OF ARMATURE BACK STOP

it is slightly clear of the armature lever when the armature is at rest. This insures that the armature (lever) springs may rest with full pressure against the back contacts without restraint from the armature back stop. The armature stop bender is tool 14769.

When the contact nearest the heelpiece is a make contact (B, D of Figure 2A), the armature back stop is adjusted to make the space between the armature and the core equal to whatever the break contact gauging would be if there were a break contact; e.g., .010 of an inch in "B" of Fig. 2A. Thus the armature spring of "B" will move the same distance to reach its make spring as the armature of "C" will after leaving its break contact. This .010" is called the "stroke adjustment."

If two or more armature springs are used on a relay and each one has an associated break contact, the armature spring (closest to the armature) is adjusted to just leave its break contact at a given value (.011" in "E"); the next armature spring is adjusted to leave its break contact at a lower value (.010" in "E"), etc. Thus the contact nearest the armature will operate first, the armature successively picking up the load of the several springs. The above adjustment insures that each armature spring rests against its associated break contact with its full tension (pressure).

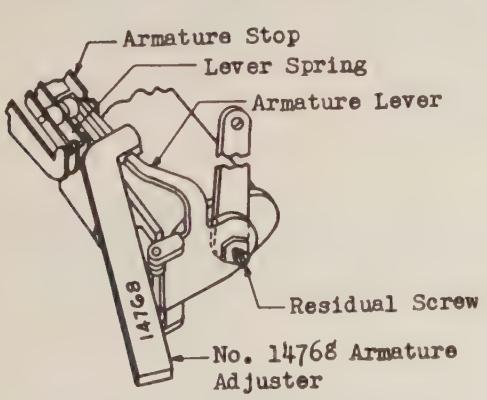



FIG. 3 ADJUSTING THE ARMATURE LEVER

Adjustment A-100 should be referred to for the general requirements covering relays, their springs bushings, wiring, etc. Refer to Figures 1 to 6 for method of adjusting the relay to conform with the gauging requirements on the Relay Adjustment ("AH") Sheets.

Relays must be gauged with the armature operated electrically as provided in the appropriate Adjustment under "Springs". On twin-contact relays, see that the two contacts make or break at approximately the same time.

1.25 Margining

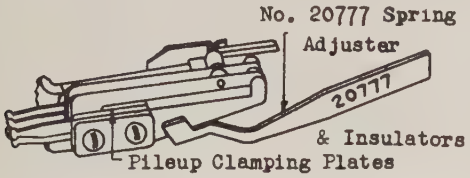
Margining is a test applied to relays to see if they meet the electrical requirements as set forth on the appropriate Relay Adjustment ("AH") Sheets. (See page G-44). Voltage at which the test is to be made is specified on the "AH" Sheet.

The relay is tested in series with a resistance of operate ("O") value to prevent the possibility of all the springs having been adjusted so as to be on the "stiff" side. If the spring gauging is correct, the relay should operate; otherwise the springs will require readjustment. Next, the relay is tested in series with a resistance of non-operate "NO" value. If there is sufficient tension in the springs, the relay will not operate with this value of resistance. This tests the back pressure in the armature springs assuring good back contacts if the load is properly distributed over the armature springs. (See A-100.)

Margining insures that a relay will operate under the required conditions of series resistance or of current value and that it will remain non-operated at other times. (See appropriate Adjustment for definition of non-operated, "NO", and operated, "O.") However, margining does not insure that contact pressure is evenly distributed and that relay springs are making proper contact. Thus margining serves as a check only on the overall spring tensioning.

1.26 Tensioning Springs

If the relay fails to meet the marginal requirements, tension of the armature springs must be adjusted. For example, if the relay operates on the "NO" (non-operate) value, it will be necessary to increase the tension in the armature (lever) springs. This is accomplished as follows: (1) bend each armature (lever) spring toward the heelpiece using spring bender tool H-42873 placed on the spring near the clamping plate end. See Figure 6. This adjustment will cause the spring to bear against its break contact with greater pressure, thus keeping the armature from operating when the "NO" value is applied. Since this adjustment may disturb the spring gauging, this must be carefully rechecked.




NOTE 3 No. 7066 right angle spring adjuster may also be used for Figs. 5 & 6.

FIG. 5 ADJUSTING SPRINGS TO MEET GAUGING REQUIREMENTS

Contact pressure must be correctly distributed over the various springs. If the relay springs need a little more tension, the above operation should be repeated. Occasionally, too much tension is put in the spring causing the relay to fail to meet the "O" (operation) margining test. If this happens, it is only necessary to perform the bending operation in reverse; i.e., bend the spring slightly *away from* the heelpiece. Should this operation fail, it will then be necessary to reshape the armature spring to its original form by removing any kinks or bends and performing the following operations: (2) bend the armature spring away from the heelpiece. Do this by placing tool H-42873 on the spring alongside the clamping plate at rear of relay and bend spring away from the heelpiece. The spring is now ready to be "Stroked"; (3) stroke the spring using tool H-42873 (Figure 6) pushing slightly outward and holding the tool at such an angle that the spring being stroked is arched outward, away from the heelpiece. The spring thus becomes slightly bowed with its concave side toward the heelpiece, or in other words the spring is curved so that its center portion is farther from the heelpiece than either the clamped portion or the contact end. From here on operation (1) should again be carried out, using care in each case to bring about the proper pressure against the associated break contact.

A. GENERAL

1. Not applicable.

2. These relays shall meet the general requirements specified in A-100, which are applicable.

3. Not applicable.

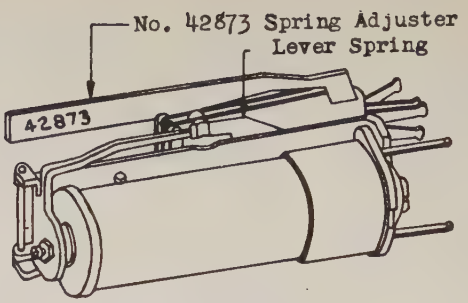



FIG. 6
ADJUSTING LEVER SPRINGS FOR TENSION

4. Type No. 28 "Z" relays (pin bearing) shall meet the requirements herein.

5. When a "Z" relay is mounted on the frame of a Strowger Switch, the relay armature shall clear the nearest point on the lower rotary magnet coil spool head by minimum 1/32".

6. Not applicable.

7. Not applicable.

8. Not applicable.

B. ALIGNMENT

1. When relays are mounted on their associated mounting plates, the relays shall be properly aligned. There shall be a minimum space of 1/32" between the armature or springs of any relay and the armature, springs, or heelpiece of the relay above, or below it, and the armature back stop of any relay shall not touch the heelpiece of the relay above it. This may be gauged visually.

2. In either the normal or operated position, there shall be a clearance of .010" minimum between springs not designed to make contact.

3. All contact springs, when assembled on the relay, shall line up uniformly with respect to each other and to the relay structure proper as gauged visually.

4. Not applicable.

5. Not applicable.

6. Spring operating bushings shall be approximately in alignment with the center of and perpendicular to the springs against which they strike, as gauged visually.

C. ARMATURE

1. The relay armature shall be set so as not to make contact with the heelpiece, but to clear the heelpiece by not more than .003" for adjustment and

.004" for inspection at the closest point with the armature operated. The armature shall be parallel to the heelpiece end, as gauged visually.

NOTE: In case of short lever, slow release relays, the maximum air gap may be .005" for adjustment and .006" for inspection.

2. The relay armature shall not bind at its bearings or on the heelpiece and shall have side play of not less than .002" or more than .020".

3. The armature back stop shall be adjusted to allow minimum .005", maximum .012", play in the armature between the No. 2 spring and the armature back stop on spring pile-ups where the No. 1 spring is a back contact. This may be judged visually. See Figure 4.

4. The "Z" relay armature back stop shall be positioned so the point of contact between the armature and the formed edge of the back stop is not less than 1/32" from the end of the armature arm.

5. The armature bushing shall be securely assembled on its associated mounting.

D. RESIDUALS

1. Relays which are equipped with adjustable residuals shall be adjusted as specified on the Relay Adjustment Sheets. This is an adjustment of the space between the core and armature with the relay electrically operated.

2. Where the residual specified on the Relay Adjustment Sheet is .003" or more, a tolerance not to exceed plus or minus .001" for Adjustment and .002" for Inspection shall be allowed except as follows:

   (a) Where the residual specified for a short lever armature relay is .003", a tolerance not to exceed plus .001" or minus .0015" shall be allowed for Adjustment or Inspection, unless otherwise specified.

3. Where the residual is specified as .0015" the armature shall not touch the core, or be more than .003" for Adjustment and .004" for Inspection, from the core at the closest point, with the armature operated electrically

E. SPRINGS

1. Relays shall be gauged between the armature (or residual screw when used) and the core, as specified on the Relay Adjustment Sheet, with the armature operated electrically according to F-1 (a) or F-1 (b). Make or break contacts should just make or break with the gauge of the value called for inserted between the armature (or residual screw, when used) and the core with the armature electrically operated. With the tolerances noted below for inspection or adjustment the associated make contacts shall not make with the plus tolerances and shall make with the minus; and the associated break contacts shall not break with the plus tolerances and shall break with the minus tolerances.

2. For Adjustment, a variation, from the values specified, or plus or minus .001" in the case of standard armatures, or .002" in the case of short lever armatures shall be allowed.

3. Upon Inspection, a variation, from the values specified, of plus or minus, .002" in the case of standard armatures, or .003" in the case of short lever armatures shall be allowed, except as follows:

   (a) When a make or break contact is specified as .003", or less, the variation allowed for Adjustment shall be plus .001" or minus -0- and for Inspection the variation shall be plus .002" or minus -0-.

   (b) When a make or break contact is specified as .004" the variation allowed for Adjustment shall be plus .001" or minus .001" and for Inspection the variation shall be plus .002" or minus .001".

   (c) On make-before-break assemblies where the difference between the values specified for the make and break adjustment is as indicated in the following table, the variation allowed for Inspection or Adjustment as determined by E2, E3 (a) or E3 (b), shall not cause the break contacts to break when a gauge is used which is the indicated amount smaller than the gauge on which the make contacts actually make.

| Difference between make and break specified | Break contacts shall not break with following size gauge smaller than gauge on which make contact actually makes | |
|---|---|---|
| .003" and .004" for slug Type C Relay of selectors | For Insp. .001" | For Adjust. .002" |
| .003" | .002" | .003" |
| .004" | .002" | .003" |
| .005" | .003" | .004" |
| .006" | .004" | .005" |
| .007" | .005" | .006" |
| .008" | .006" | .007" |
| .009" | .007" | .008" |
| .010" | .008" | .009" |
| .011" | .009" | .010" |
| .012" | .010" | .011" |

These tolerances shall be checked with gauges which vary in steps of .001".

   (d) Where a stroke measurement is specified, the variation allowed for inspection shall be as follows:

      1. A gauge .003" in the case of standard armature and .005" in the case of a short

lever armature larger than the specified stroke gauging should not enter between the armature (or residual screw, when used) and the core when the relay is not energized, or if it does enter the armature shall not leave the armature back stop when the relay is electrically energized.

2. When the difference between the values specified for stroke gauging and the highest make contact gauging is .005" or more, the armature shall leave the back stop when a thickness gauge of .002" less than the values specified for the stroke is inserted between the armature (or residual, when used) and the core.

3. When the difference between the values specified for the stroke gauging and the highest make contact gauging is .004" or less, the armature shall leave the back stop when a thickness gauge of .002" more than the value on which the make contact actually makes, (gauged within .001"), is inserted between the armature or residual screw, when used) and the core.

(e) When there are two or more back contacts in a spring pile-up, the variation allowed shall not change the sequence of operation, as indicated by the specified mechanical gauging.

NOTE: The above requirement does not apply to the back contacts of the standard make-before-break assemblies as illustrated by springs No. 2 and No. 3 of Figure 7.

(f) When the gauging specified for a make contact assembly is .004", or more, greater than any other make contact gauging value for the same relay, no variation shall be allowed that will alter the sequence of operation indicated by the .004" or more difference.

(g) When the difference between the values specified for the break and make springs of a break-make assembly is .002" or less, the make springs shall not make when a gauge is used which is .002" less for Adjustment or .001" less for Inspection, than that on which the break contacts actually break. When the difference between the values specified for the break and make springs of a break-make assembly is .003" or more, the make springs shall not make when a gauge is used which is .002" less than that on which the break contacts actually break.

4. When the gauging or separate electrical requirements indicate that one or more pairs of contacts shall make or break before the next succeeding pair of contacts break, they shall be adjusted as follows:

(a) When the gauging difference between the pairs of contacts is .006" or more, the make or break contacts shall make or break before the bushing on the armature spring of the succeeding pair of break contacts is struck by the preceding armature spring.

(b) When the gauging difference between the pairs of contacts is .005" or less, the make or break contacts may or may not make or break before the bushing on the armature spring of the succeeding pair of break contacts is struck by the preceding armature spring, but the make or break contacts must make or break before the succeeding break contacts break.

5. Variation in the mechanical gauging shall not be permitted which will allow the normal or operated contact gap to be less than .005" as gauged by eye.

6. Relays shall fully operate all springs and the armature (or residual screw, when used) shall touch the core on the "Operate" tests shown on the Relay Adjustment Sheet.

7. Relays shall not open any back contact circuits nor close any make contact circuits on the "non-operate" tests shown on the Relay Adjustment Sheets except as follows:

(a) On Relays having three or more back contacts the first two back contacts assemblies in the sequence of operation as indicated by the specified mechanical gauging, may break contact on the "non-operate" tests shown on the Relay Adjustment Sheets.




FIG. 7 STANDARD MAKE - BEFORE BREAK ASSEMBLY




FIG. 8 SPECIAL MAKE - BEFORE BREAK ASSEMBLY

NOTE: The above requirement does not apply to the back contacts of the standard make-before-break assemblies as illustrated by springs No. 2 and No. 3 of Figure 7. However, the above requirement applies to the back contacts of the special make-before-break assemblies as illustrated by springs No. 1 and No. 2 of Figure 8.

(b) On special make-before-break contact springs as illustrated by Figure 8, the make contacts may make on the non-operate requirements specified for the entire spring combination.

(c) On two step relays the contacts to which the separate electrical requirements apply may make or break on the "non-operate" requirements specified for the entire spring combination.

8. Spring tension shall be accurately adjusted in accordance with the "adjust" values (current or resistance), and inspected in accordance with the "Test" values (current or resistance) shown on the Relay Adjustment Sheets.

9. A variation of plus or minus one volt shall be allowed in the voltage specified for adjusting and inspecting the relays according to the "Adjust" and "Test" resistance values.

10. Not applicable.

11. Not applicable.

F. SATURATION

1. Relays shall be saturated at a minimum of 300 ampere turns for a minimum interval of one second before being adjusted or checked to the electrical current flow requirements. The saturating current shall be in the same direction as the other current flow requirements. The other current flow requirements shall not be applied until a minimum interval of one second after saturation.

(a) When adjusting and testing on 46 volts this requirement may be met by applying the voltage to the operating winding as follows: Windings of a 100 ohm resistance or more, connect directly to 46 volts ±1 volt. Windings of less than 100 ohms resistance, connect to 46 volts ±1 volt with a protective resistance of approximately 45 ohms (or switch magnets) in series.

(b) When adjusting and testing on 24 volts this requirement may be met by applying the voltage to the operating winding as follows: Windings of 25 ohms resistance or more, connect directly to 24 volts ±1 volt. Windings of less than 25 ohms resistance connect to 24 volts ±1 volt with a protective resistance of approximately 12 ohms (or switch magnets) in series.

G. NOT APPLICABLE

H. NOT APPLICABLE

## ADJUSTMENT A-120
## FOR
## OFF NORMAL SPRING ASSEMBLIES ON STROWGER SWITCHES

A. GENERAL

1. The off-normal spring assemblies shall meet the general requirements specified in A-100 which are applicable

B. VERTICAL OFF NORMAL ASSEMBLIES

1. The springs shall be approximately parallel with the shaft when the switch is at normal.

2. There should be perceptible clearance between the lever bushing and the first lever spring, with the off-normal lever in its highest position; but this clearance shall not be great enough to cause a bind between the normal stop pin and the off-normal lever, such as to prevent the restoration of the shaft when it is released from the third contact of the first level.

3. Where a lever spring has an adjacent back contact, there should be a minimum space of .002" between the lever spring and the bushing of the lever spring of an adjacent back contact assembly when the shaft is off normal.

4. The minimum contact separation shall be .008" for make or break contacts. Similar assemblies shall be adjusted in a uniform manner.

5. There should be .010" minimum between the off-normal lever and the normal pin, with the switch up one and in one.

6. Not applicable.

7. Not applicable.

8. With the shaft off-normal, the lever springs shall be tensioned against the make contacts sufficiently to insure good contact, but the combined tension of the vertical off-normal springs shall not be sufficient to prevent the complete restoration of the shaft to vertical normal from any position between the first level and vertical normal.

9. Not applicable.

10. The adjustment of off-normal assemblies shall be checked for sufficient closure of make contacts, by noting that they are in mechanical contact when a gauge of .020" thickness is inserted between the clamp holding the normal pin to the shaft and the shaft bearing.

C. ROTARY OFF NORMAL ASSEMBLIES

1. The minimum contact separation shall be .006" for make or break contacts. Similar assemblies shall be adjusted in a uniform manner.

2. Contacts shall break contact before the double dog drops in on the first rotary step.

3. The roller shall be free on its bearing. The roller bracket shall not foul the rotary hub.

   The roller spring shall be tensioned to bear lightly on the mounting bracket when the shaft is normal. There shall be a perceptible clearance between the roller and the cam before the first rotary step.

4. With the shaft at normal, the lever spring is adjusted at the factory to have a tension of 25 grams minimum against the mounting bracket.

5. Not applicable.

## ADJUSTMENT A-121
## FOR
## SHAFT SPRINGS ON
## STROWGER SWITCHES

A. GENERAL

1. The spring parts shall meet the general requirements in A-100 which are applicable.

B. TENSION

1. When the switch is assembled with its associated bank or banks, the tension of the shaft spring shall be sufficient to restore the shaft to rotary normal, from the second rotary step of the first bank level, when retarded lightly by hand. When meeting this requirement the shaft spring shall not be wound with more than 2¾ turns, one turn being considered a 360° rotation of the shaft spring cap.

2. On switches equipped with vertical wipers, the spring shall be tensioned to hold the normal pin firmly against the normal stop during the vertical impulses.

## ADJUSTMENT A-122
## FOR
## STROWGER SWITCH CAM SPRINGS

A. GENERAL

Parts shall meet the general requirements specified in A-100 which are applicable.

B. GAUGING

1. There shall be a perceptible clearance between the closest point on the cam collar, and the spring stud which engages the cam; but this clearance shall not exceed 5/64".

2. There shall be a perceptible clearance between the rotary ratchet, and the spring stud which engages the cam; but this clearance shall not exceed 1/16".

3. The minimum contact separation for make or break contacts shall be .006".

4. Where there are two or more adjacent break contact assemblies, there shall be minimum space of .002" between each lever spring and the bushing of the lever spring in the adjacent break assembly.

5. There shall be a perceptible clearance between the cam and bushing when the shaft is on the rotary step preceding the one on which the springs are to operate.

6. Not applicable.

C. TENSION

1. Make or break springs shall have a perceptible follow when making or breaking contact.

2. Not applicable.

3. Not applicable.

4. Not applicable.

D. NOT APPLICABLE.

# ADJUSTMENT A-130 FOR STROWGER SWITCH VERTICAL MECHANISM

A. GENERAL

1. Parts shall meet the general requirements specified in A-100 which are applicable.

B. ARMATURE

1. The vertical armature shall not bind nor have more than .012" side play.

2. With the magnets electrically operated, the vertical armature shall strike both magnet cores. This requirement is satisfactorily met if the space between the armature and the closest point on either core does not exceed .002".

3. With the vertical magnets electrically operated, and with the vertical pawl engaged with the vertical tooth corresponding to each level:

   (a) There shall be a perceptible play between the vertical pawl and casting (overthrow stop), with the shaft at rest.

   (b) There shall be a gap between the top of the vertical dog and the under surface of the vertical tooth not to exceed .010" with the shaft raised by hand so that the vertical pawl is resting against the casting (overthrow stop).

4. With other vertical requirements met, the vertical armature spring shall be tensioned for satisfactory operation, with the routine test set.

C. PAWL

1. The vertical pawl shall not bind and the maximum side play shall be .008" with relation to the armature.

2. There shall be a clearance of minimum .010" between the vertical pawl finger and the vertical pawl guide just as the shaft starts to move vertically under the control of the vertical armature.

   NOTE: This requirement shall be met on all steps.

3. The pawl shall clear the vertical teeth as the shaft releases and shall clear the rotary hub when the shaft is up ten.

4. With the vertical pawl resting on the shoulder of the vertical ratchet above the first tooth, both corners formed by the arc at the pawl tip shall contact the periphery of the shoulder in some one position permitted by the side play of the vertical armature.

5. The opening in the loop of the pawl spring after it is attached to the pawl shall not exceed 5/64".

D. INTERRUPTOR SPRINGS

1. The interrupter arm shall not bind on its bearing, and shall have perceptible side play not to exceed .015".

2. The lever spring shall be tensioned against the interrupter bushing. This tension is adjusted to be between 25 and 100 grams at the factory.

3. Contacts shall make on .010" ±.002" gauged between armature and coil cores.

4. With the interrupter arm at normal, there shall be min. .015", max. .025" clearance between the contacts.

E. Not applicable.

# ADJUSTMENT A-131
# FOR
# STROWGER SWITCH DOGS

## I. INTRODUCTION

This adjustment contains the requirements for Double Dogs and Stationary Dogs of Strowger Switches. For the inspection and adjustment of only the switching mechanism, adjustments A-130 (vertical mechanism) A-132 (rotary mechanism), and A-133 (release mechanism) will be necessary together with this adjustment.

For the complete Adjustment of a switch, the following Adjustments may also be required: A-100 General Requirements, A-101 Jacks, Covers and Bases, A-120 Off-Normal Assemblies, A-121 Cup and Shaft Springs, A-122 Cams, and A-135 Shafts, Wipers, and Banks.

The "double dog" is made up of two detents, one of which engages the vertical teeth of the shaft and the other engages the rotary teeth. It is held by spring tension against the shaft but is pivoted so that the release armature upon operation strikes it and disengages it from the shaft. Its function is to prevent the shaft from restoring to normal either in a rotary or vertical direction, except upon operation of the release magnet. The upper detent of the double dog which rides on the vertical teeth is called the "vertical dog" and the lower detent which rides on the rotary teeth is called the "rotary dog."

The "stationary dog" is located on the left side of the switch. It is made up of two arms—the upper one is the stationary dog and it rides in a slot in the vertical teeth of the shaft. Its purpose is to support the shaft during the rotary motion and yet allow the shaft to move vertically when it is at rotary normal The lower arm is the vertical pawl guide and its adjustment is contained in A-120.

## II. ROUTINE INSPECTION

After determining, (1) that there are no binds in the switch shaft, or the vertical and rotary armatures; and (2) that the shaft spring, the vertical armature restoring spring, and the rotary armature restoring spring have proper tension (see adjustments A-130 and A-132):

1. Check the vertical play of the double dog. Section III-B-1.

2. Straighten and tension double dog spring. Section III-B-5 and 6.

3. Check rotary dog. Section III-B-7. The rotary dog should not be bent to meet this requirement. If it does not engage the teeth properly, the double dog should be removed and replaced.

The rotary pawl, normal stop pin, rotary armature stop, release mechanism, vertical pawl, and vertical magnets should then be inspected in the above order and adjusted if necessary. (See adjustments A-132, A-133 and A-130.)

1. Inspect (and adjust if necessary) the vertical dog. Section III-B-2, 3 and 4. The vertical magnets should be energized when checking III-B-3.

2. Inspect (and adjust if necessary) the stationary dog. Section III-C. If this adjustment has been made properly there will be a gap between the top of the vertical dog and the under surface of the vertical tooth, not to exceed .010" with the shaft raised by hand so that the vertical pawl is resting against the casting (overthrow stop).

The vertical pawl guide arm, the off-normal springs, the rotary magnets, the rotary pawl front stop, the interrupter springs, and the cam springs should then be adjusted in the above order (see adjustments A-130, A-120, A-132 and A-122).

## III. SPECIFIC REQUIREMENTS

### A. General

Parts shall meet the general requirements specified in A-100 which are applicable.

### B. Double Dog

1. The double dog shall not bind nor have more than .002" vertical play.

2. The tip of the vertical dog, when unlatched, shall ride within the notches in the vertical ratchet with the shaft at rotary normal.

3. It shall drop in on all levels and may allow a perceptible drop (.003") in the shaft on some levels but shall not allow a perceptible drop (.003") in the shaft on all levels.

4. With the shaft at rotary normal and the double dog disengaged from the release link, there shall be a minimum of .002", maximum .010" outside play of the shaft without moving the vertical dog. This requirement shall be met on all levels except the 10th.

5. The double dog spring shall be free from unnecessary bends and shall have not more than .025" bow. The vertical center line of its broad surface shall be approximately parallel to the shaft.

6. Unless otherwise specified, with the double dog engaged in the release link, the double dog spring is adjusted at the factory to have a tension of at least 250 grams but no more than 400 grams measured just above the double dog.

7. The stopping face of the rotary dog shall engage approximately flat with the radial face of the rotary teeth.

C. Stationary Dog

1. The stationary dog shall be adjusted, in the slot in the vertical shaft, to clear the teeth of the shaft by .003" maximum at the nearest point when the normal bracket is pressed against the normal post from the left.

2. The stationary dog shall not cause a rise (as gauged visually), and shall not allow more than a perceptible (.003") drop of the shaft, as it cuts in on at least one level. With the rotary magnets energized on the first rotary step, the shaft shall rest on the stationary dog so that the vertical dog will drop all the way in when pulled away from the shaft and released.

3. It shall allow a vertical movement of the shaft of .002" min. .010" max. with the shaft cut in two or more steps on any level. This test shall be made with the double dog held away from the shaft.

D. Not Applicable.

## ADJUSTMENT A-132 FOR STROWGER SWITCH ROTARY MECHANISM

A. GENERAL

1. Parts shall meet the general requirements specified in A-100 which are applicable.

B. ARMATURE

1. The rotary armature shall not bind nor have more than .003" vertical play, and shall strike both magnet cores at the same time, with the magnets electrically operated. The latter requirement is satisfactorily met if the space between the armature and the closest point on either core does not exceed .002".

2. The magnet shall be so located that, when energized, there shall be a space of minimum .005", maximum .010", between the rotary dog and at least one of the first ten teeth of the fifth bank level.

NOTE: This requirement shall be met with the coils at approximately room temperature.

3. With the rotary armature in its non-operated position—

(a) The rotary armature shall overlap a minimum of two-thirds the diameter of the back stop, as gauged visually.

(b) The rotary pawl shall entirely overlap the end of the rotary pawl guide.

4. With other rotary requirements met, the rotary armature spring shall be tensioned for satisfactory operation, with the routine test set.

C. PAWL

1. The rotary pawl shall be free from bind.

2. The rotary pawl tip shall strike in the notch of the rotary teeth within the following limits:

(a) It shall not strike upon the radial face of any tooth.

(b) It shall strike the base of the notch between the teeth or between this point and the center of the flank of a tooth.

3. With the rotary magnets energized, the clearance between the rotary pawl and its front stop shall be minimum .002", maximum .006" at the first, fifth and tenth rotary steps on the fifth bank level.

NOTE: This requirement shall be met with the coils at approximately room temperature.

4. The normal pin shall be set so the pawl strikes the first tooth in the same relative position that it strikes the other teeth.

5. The rotary armature stop shall be set to allow the shaft to release from any level without striking the pawl and to have from .002" to .010" clearance between the pawl and the shaft with the shaft at normal.

6. The opening in the loop of the pawl spring after it is attached to the pawl shall not exceed 5/64".

7. The rotary pawl shall strike the shaft hub squarely when the rotary armature is operated manually.

NOTE: This requirement is intended to govern two conditions; that is,

(a) the tip edge of the pawl shall be parallel with a vertical plane tangent to the shaft hub at the point where the pawl contacts with the hub, and

(b) the tip edge of the pawl shall be parallel with a radial plane through the base of the last vertical notch in the hub. Both of these conditions shall be checked with the shaft on the last rotary step of the ninth or tenth (or in case of single level switches, the operating) level.

D. INTERRUPTER SPRINGS

1. Selectors and Connectors

a. The interrupter springs shall break contact as specified below with rotary magnets energized, unless otherwise specified.

When used with interrupter relays; .003" min., .008" max.

When interrupting own circuits; .007" min., .015" max.

b. The rotary interrupter springs are factory adjusted to have a contact pressure of 150 grams minimum, 300 grams maximum, measured at the end of the spring with the rotary magnets de-energized.

2. Finders

a. The lever spring shall leave its back stop at .010" ±.002" and the contacts shall make at .006" ± .002" gauged between armature and coil cores.

b. The lever springs are factory adjusted to bear on the back stop with a tension between 25 and 150 grams.

## ADJUSTMENT A-133 FOR STROWGER SWITCH RELEASE MECHANISM

A. GENERAL

1. The release mechanism shall meet the general requirements listed in A-100 which are applicable.

B. LINK

1. With the double dog latched in the release link and with the switch shaft on the fifth vertical level there shall be a minimum .030", maximum .045" space between the engaging edge of the dog and the outside periphery of the rotary teeth.

2. Not applicable.

C. ARMATURE

1. With the release armature at rest, in its electrically operated position, the pin shall hold the double dog so that the release link drops completely over the double dog lug.

NOTE: The operated position referred to, is the position, with respect to side play that the release armature assumes when the release magnet is energized, de-energized and again energized

2. With the release magnet energized, and the release armature at rest in its normal position with relation to the release magnet bracket, and a .006" gap between the release armature and the closest point on the core, the release link shall not latch the double dog.

NOTE: The operated position referred to, is the position, with respect to side play that the release armature assumes when the release magnet is energized, de-energized and again energized.

3. The back stop screw shall be set to allow .060" min. .120" max. space between the double dog and the end of the armature pin when the release armature is at normal and the shaft is at rest in any off normal position with the rotary dog resting on the rotary ratchet.

D. OPERATING REQUIREMENTS

1. The release magnet shall operate the double dog and release the shaft from any point on .180 ampere.

NOTE: This requirement shall be checked by operating the magnet on 46 plus or minus 1V with 140 ohms in series with it.

2. The magnet armature shall release on open circuit after being operated on a current of .365 ampere; that is, with 10 ohms in series with it.

E. RELEASE CONTACT SPRINGS

1. The contact springs shall make contact just after the rotary dog clears the teeth on the rotary shaft, unless otherwise specified on switch adjustment sheet.

2. The contacts shall have a contact separation of minimum .008" unless otherwise specified in switch adjustment sheet.

3. The lever spring shall be tensioned against the operating bushing, but this tension shall not be sufficient to interfere with the release of the switch when the release armature is slightly retarded.

# ADJUSTMENT A-135
# FOR
# STROWGER SWITCH SHAFTS, WIPERS & BANKS

## A. GENERAL

1. Parts shall meet the general requirements specified in A-100, which are applicable.

## B. LINE AND PRIVATE WIPERS AND BANKS

1. The wiper assembly shall be at approximately right angles to the switch shaft so that the upper and lower wiper tips will rest at approximately equal angles on the bank contacts.

2. The wiper springs shall be approximately in vertical alignment with each other at their tip ends.

3. The wiper springs shall be approximately 1/8" apart at the point where the straight portion of the spring forms into the hub end. At that point there should be a sharp bend in the spring and the two springs should converge in an approximately straight line to the ends of the insulator.

4. The tension of the springs, when on the banks should be entirely against the bank contacts and not against each other thru the separating insulator.

5. Only the tips of the wipers shall rest on the bank contacts.

6. The wipers shall center on the fifth or sixth contacts of the first and tenth levels (except as noted in Section B-7). If, when placed on the first and tenth contacts of these levels the wipers do not center approximately, they shall rest either as far to the right of the center on the tenth as they do to the left of the center on the first; or as far to the left of the center on the tenth as they are to the right of the center on the first.

7. Not Applicable.

8. The bank wipers shall overlap the end of each associated bank contact by at least 1/16". This requirement shall be checked on the first and tenth contacts of the first and tenth bank levels.

9. With the play between the normal bracket and the left side of the normal post, taken up by applying a light pressure to the normal bracket near the normal post, the wipers shall not touch the banks when moving vertically.

10. The tips of the wipers shall not be changed from their original form.

11. The centerline between the tips of the springs on the wiper assembly shall coincide within ±1/64" with the centerline of the fifth contact level (unless otherwise specified below) of the associated bank, when the wiper is about to cut in on the first contact of that level.

12. Not Applicable.

13. Unless otherwise specified, the springs of all two-conductor wipers shall be approximately .015" apart at their tip ends.

14. Unless otherwise specified, the springs of all single conductor wipers shall touch at their tip end. There shall be a minimum of perceptible and maximum of .015" clearance between one of the springs and the associated insulator at the bend of the spring nearest the end of the insulator with the insulators held together against the other spring.

15. The wiper springs of each assembly shall be tensioned so that when the pressure of one spring in the pair is removed from the other, both springs shall have a follow of at least 3/32" and one of them not more than 9/64".

16. The bank rod collar assemblies shall secure all banks in place and the topmost bank shall be in contact with at least one of the two bank rod assembly locating shoulders.

## C. VERTICAL WIPERS AND BANKS

1. The centerline of the vertical wiper shall be approximately at right angles to the shaft.

   NOTE: In adjusting the wiper, the tip shall not be changed from its original form.

2. The vertical bank shall be mounted with its centerline approximately parallel to the shaft.

3. Only the tip of the wiper shall rest on the bank contacts.

4. With the shaft in position to cut in on any level, the centerline of the commutator wiper shall not be more than 1/32" above nor more than 1/64" below the centerline of the commutator contact corresponding to that level.

5. Vertical wipers are tensioned against the bank contacts at the factory to provide a minimum 30 grams, maximum 45 grams measured at the offset in the wiper between the straight portion and the tip. With the shaft on the first rotary step of any level the tip of the vertical wiper shall clear the bank contact.

6. With the shaft on the first vertical step and held in the rotary position in which the wiper back stop just lifts the wiper spring from the associated vertical bank contact, the end of the vertical wiper spring and the vertical bank contact shall overlap by at least 5/64".

   NOTE: This requirement will be met if the back edge of the wiper spring shoe is approximately in alignment with the end of the vertical bank contact. In checking this requirement the shaft should be held at a point above the top bearing.

7. The end of the back stop of the vertical wiper shall clear the wiper spring with the shaft at rotary normal on all levels.

D. NOT APPLICABLE.

E. SHAFTS

1. The shaft shall return to its rotary normal position when released mechanically from contact #11.

2. The shaft shall be sufficiently free from bind in its bearings to restore vertically from rest at any non-cut-in position by its own weight, with the off normal finger fully depressed manually.

3. The shaft is in the normal position when the normal pin bracket is resting upon the upper shaft bearing.

4. Not Applicable.

5. With the shaft on the last rotary step of the first bank level, there shall be a perceptible clearance between the normal pin bracket and the off normal finger.

# ADJUSTMENT A-136 FOR MINOR SWITCH

## A. GENERAL

1. The minor switch shall meet the requirements, specified in A-100, which are applicable.

## B. WIPER ASSEMBLY

1. The wiper assembly nut shall be securely tightened.
2. The upper spring of each pair of wipers shall not be out of alignment (vertically) with the lower spring of a wiper more than 1/64".
3. The upper wiper shall not be out of alignment (vertically) with the lower wiper of a wiper assembly more than 1/32" unless otherwise specified on the wiper assembly drawing.
4. The tips of a pair of wiper springs shall be separated approximately .015" with the wiper off the bank.
5. Each wiper spring shall be tensioned to have a follow of approximately 1/16" (measured at the tip) when its opposing spring is deflected.
6. The springs of a wiper shall exert approximately equal tension on the bank contacts so that there shall be no perceptible rise or fall in the wiper as a whole, as it passes onto or off the bank.
7. The wiper assembly shall not bind on its axis nor shall it have more than .005" vertical play.
8. The off-normal arm roller shall turn freely on its axis.
9. The normal finger shall make contact with the normal stop pin for at least 1/64".
10. The normal finger shall not make contact with the wiper assembly restoring spring as the wipers operate or restore.
11. The wiper assembly restoring spring shall have just enough tension to restore the shaft to normal from the second bank contact when the shaft is retarded by hand.
12. When the oil slot does not extend to the end of the shaft, the oil hole in the wiper assembly collar shall be in approximate alignment with the oil slot in the shaft.

## C. BANKS

1. The bank assembly shall be set, with the wiper assembly at normal, so that the wiper tips rest at a distance from the first contact, approximately equal to one rotary step of the wipers (or approximately equal to the distance between the centers of two adjacent bank contacts).
2. The bank assembly shall be set so that the tips of the wipers pass over the approximate center of the visible length of each bank contact, and come to rest approximately on the center of each bank contact, with respect to the width of the contact.

## D. RELEASE ARMATURE AND COUNTERBALANCE

1. The inner surface of the release armature shall be approximately parallel to the end of the heelpiece.
2. The armature shall clear the heelpiece, and the gap between the armature and heelpiece with the armature electrically operated shall be maximum .004".
3. The release armature shall not bind on its bearings or on the heelpiece and shall have perceptible side play.
4. The release armature shall have a stroke measured between the armature and coil core .020" plus or minus .002" unless otherwise specified on the associated relay adjustment sheet.
5. The engaging surface and edge of the ratchet dog shall be well aligned with the ratchet teeth and shall be adjusted to hold the wiper tips approximately on the centers of the bank contacts.

6 Not Applicable.

7. The release armature spring shall be tensioned as specified on the associated relay adjustment sheet.
8. The counterbalance shall not bind on its bearing.
9. There shall be minimum .020" clearance between the counterbalance and the bank clamping screw.

   NOTE: The embossings at the end of the counterbalance may touch the frame.

10. There shall be perceptible to .008" play between the release magnet armature and the jaws of the counterbalance.

## E. ROTARY ARMATURE

1. The inner surface of the rotary armature shall be approximately parallel to the end of the heelpiece.
2. The armature shall clear the heelpiece, and the gap between the armature and heelpiece

with the armature electrically operated shall be maximum .004".

3. The rotary armature shall not bind on its bearings or on the heelpiece and shall have perceptible side play.

4. The rotary armature back stop shall be set to allow an armature stroke (measured) between the armature and coil core) of .030", plus or minus .002" unless otherwise specified on the associated relay adjustment sheet. With the above adjustment the rotary pawl will just clear the ratchet teeth when the armature is in its normal position.

5. The depth of the rotary armature stroke shall be set so that the ratchet dog drops in on each ratchet tooth with a maximum clearance of .006" between the ratchet dog and tooth when the armature is operated electrically.

6. The rotary armature spring shall clear the end of the armature at all times and shall be set with its lower edge approximately parallel to the main surface of the frame.

7. The end of the rotary armature spring shall ride freely on its bearing point on the frame.

8. The surface of the frame on which the rotary armature spring bears shall be smooth.

9. The rotary armature spring mounting screws shall not strike the rotary magnet as the armature operates.

10. The rotary armature spring shall be tensioned as specified on the associated relay adjustment sheet.

NOTE: When the associated adjustment sheet specifies testing with the wipers on the 10th contact, the armature need not operate completely on the operate requirements.

F. PAWL

1. The pawl shall be well aligned with the ratchet teeth, shall operate freely on its bearing and shall not bind on the switch frame.

2. The pawl spring is adjusted at the factory to hold the pawl guide arm against the switch frame with a pressure of minimum 50 grams, maximum 100 grams.

3. The pawl guide arm shall be set, with the wiper assembly rotated one or more steps, so that there is a space of approximately .015" between the pawl guide arm and the switch frame just before or just as the wiper assembly begins to move.

4. The normal finger shall be set so that the pawl strikes the tenth tooth of the ratchet, counting clockwise from the restoring spring hook, in the same relative position in which it strikes the other teeth. Requirement C-1 will have to be checked if it is necessary to bend the normal finger.

5. The rotary armature shall strike the core before the pawl strikes stop. With the rotary armature electrically operated, there shall be rotary play in the wiper assembly, but this play shall not exceed .020" measured at the wiper tips.

G. OFF-NORMAL SPRING ASSEMBLY

1. With the wipers resting on the first bank contact, there shall be perceptible clearance between the off-normal arm bushing and the main lever spring.

2. Make or break contact assemblies shall have a minimum contact separation of .008".

3. With the wiper assembly off-normal, the lever springs shall be tensioned against the make contacts sufficiently to insure good contact but the tension shall not be great enough to prevent the release of the switch from the first step. Back contact springs shall have perceptible follow as the wiper assembly moves off normal.

4. With the wipers resting on the first bank contact, the bushing on the first lever contact spring may touch the main lever spring, but the stud of the first lever contact spring shall not follow when the main lever spring is deflected sufficiently to clear it.

5. The flat part of the bent end of the operating spring shall normally rest approximately on the center of the length of the off-normal roller.

6. The off-normal arm bushing shall engage the curved tip of the first lever spring so as to insure the proper restoration of the spring assembly when the wipers are released from either the first or last bank contact. The off-normal arm shall not cause the first lever spring to become unnecessarily bent or bowed as it is engaged by the off-normal arm bushing.

7. The off-normal spring assembly bracket shall not prevent the wiper assembly from rotating onto the tenth contact.

8. The operating spring shall clear the end of the rotary armature with the armature operated and the wiper assembly off-normal.

# ADJUSTMENT A-173 FOR TWIN CONTACT HORIZONTAL RELAYS

## A. INTRODUCTION

Adjustment A-173 is largely a duplication of Adjustment A-110. Therefore in this edition, many sections have been deleted without comment. Those that remain show adjustments peculiar to twin contact relays.

## B. ALIGNMENT

4. A gradual bow of .025" in the free length of any spring is permissible, but there shall be no sharp bends or kinks in the spring due to adjustment.

   NOTE: Armature springs may also be bowed from armature or spring bushing to contact end of spring when operated or normal—provided the above requirement is met when springs are not making contact.

## E. SPRINGS

2. Same as A-110.

3. For final inspection plus or minus .002" shall be allowed, unless otherwise specified for standard armatures and plus or minus .003" for short lever armatures. One of two pairs of associated twin contacts may be outside these tolerances in either direction unless otherwise specified if the two pairs make or break together within .008" measured at the contact as judged visually.

   NOTE: Plus or minus .003" shall not be allowed for inspection of relays with short lever armatures if such allowance reduces normal or operated contact gap, or if a break of a break-make assembly, just breaks at less than .005".

   (a) Same as A-110.

   (b) On make-before-break assemblies where the difference between the values specified for the make and break adjustment is as indicated in the following table, the variation allowed for inspection as determined by E3 or E3a shall not cause the last break contact of the pair to break when a gauge is used which is the indicated amount smaller than the gauge on which the first make contact of the pair actually makes:

| Difference between make and break specified | The last break contact of a pair shall not break with the following size gauge smaller than the gauge on which the first make contact of a pair actually makes |
|---|---|
| .010 | .008" |
| .011 | .009" |
| .020 | .016" |

These tolerances shall be checked with gauges which vary in steps of .001".

   (c) Where a stroke measurement is specified, the variation allowed for inspection shall be as follows:

4. When the gauging or separate electrical requirements indicate that one or more pairs of contacts shall make or break before the next succeeding pair of contacts break, they shall be adjusted as follows:

   (a) When the gauging difference between the pairs of contacts is .011" or more, the first make or break contact shall make or break before the bushing on the armature spring of the succeeding pair of break contacts is struck by the preceding armature spring.

   (b) When the gauging difference between the pairs of contacts is .010" or less, the first make or break contacts may or may not make or break before the bushing on the armature spring of the succeeding pair of break contacts is struck by the preceding armature spring, but both the make or break contact must make or break before the succeeding break contacts break.

# ADJUSTMENT A-805
# FOR
# TYPE 24 DIAL

## 1. INTRODUCTION

In this Adjustment certain matter has been removed which is not applicable, and preliminary sections have been added to cover certain points of an educational nature.

## 2. DIAL ADJUSTMENTS

### 2.1 General Information

For description of the operation of a dial and the relation of the various parts, see Part A of this book. Figure 1 is a cross section view of the dial and is presented here to help further in the identification of the various parts of the dial. Frequent reference to this figure will aid in making the required adjustments. Notice that the impulse spring assembly and the shunt spring assembly are not shown. These, however, are clearly shown in the photograph in Part A. Should it become necessary to remove a dial, the electrical connections to the dial are easily and quickly disconnected as the terminals are of the screw type. A soldering iron is not required.

### 2.2 Tension in Main Spring

As indicated in Part A, the helical-wound main spring provides the driving power. The lower end of the spring is hooked over one of three hooks on the base plate, the particular hook used determining the amount of tension in the spring. The normal tension is one to one and a third turns with the dial at normal (the maximum of one and a third turns should be used for operation at low temperatures).

The tension of the spring is increased or decreased by removing the spring and then remounting the spring with the lower end engaging the hook back of, or in front of, the previously used hook, as the case may be.

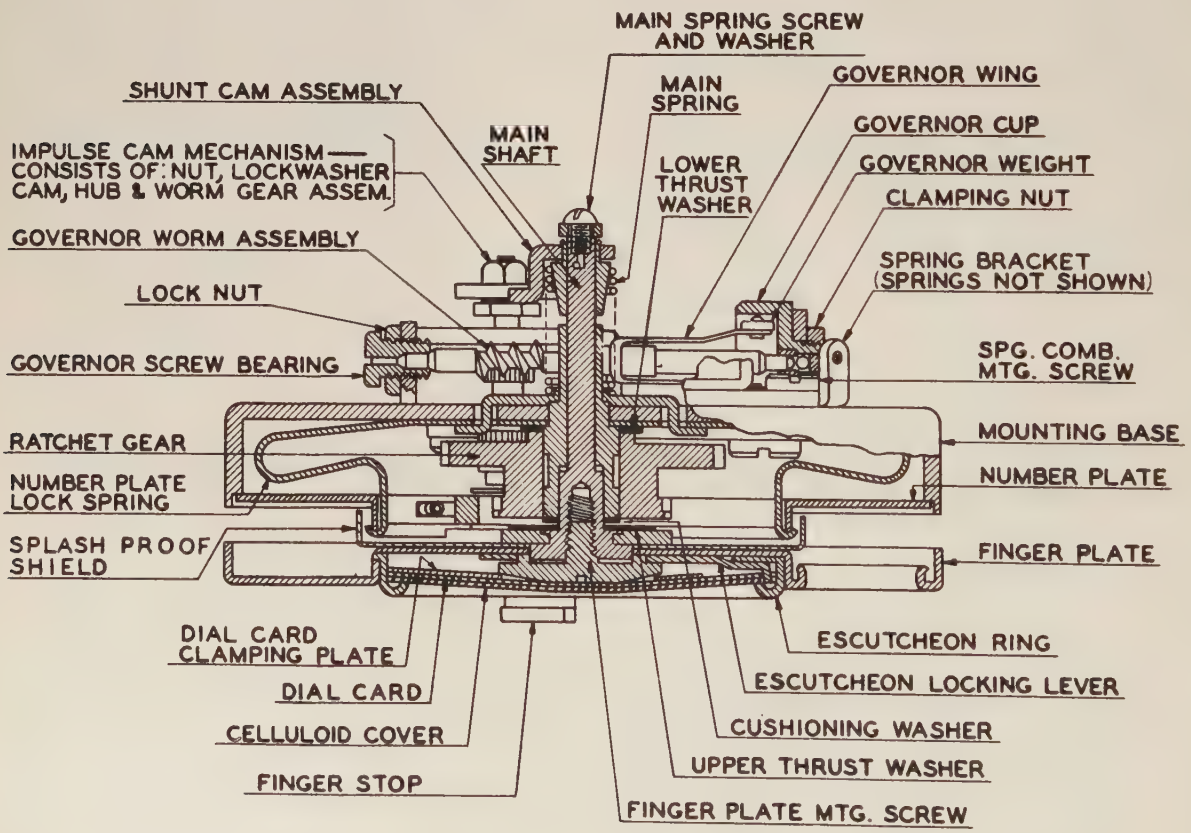



FIG. 1 DIAL MECHANISM

To remove the spring, first remove the main spring screw and washer (see Figure 1). Hold the finger plate in the normal position, turn the shunt cam assembly in a counter-clockwise direction and line up the upper end of the spring with the slot in the main shaft, lift the shunt cam assembly (the spring will come with it) and permit the spring to unwind. Unhook the lower end, and lift the spring clear. To remount the spring with a tension of one turn, hold the finger plate in the normal position. Slip the spring over the main shaft, line up the impulse shorting arm of the shunt cam assembly in approximately its correct position with respect to the impulse spring assembly and then hook the lower end of the main spring behind the nearest hook on the base plate. Twist the main spring in a counter-clockwise direction slightly more than one full turn, insert the upper end into the slot of the main shaft, press downward, and then release. Replace the main spring screw and washer.

To remount the spring with a tension of one and a third turns, proceed as outlined in the preceding paragraph with the two following exceptions: (1) line up the impulse shorting arm of the shunt cam assembly halfway between the impulse spring bracket and the shunt spring bracket, and (2) twist the spring slightly more than one and a third turns.

2.3 Speed of Dial

During manufacture, the dials are adjusted to a speed of approximately ten impulses per second.

To regulate the speed of the dial, adjust the governor wings to increase or decrease the tension of the governor weights on the inside surface of the cup. Form the governor wings as nearly alike as possible. There should be perceptible end play in the governor worm shaft but this end play should not exceed the value stated in Section D-1.

To remove the governor worm shaft, remove the impulse and shunt spring bracket assembly and the main spring. Loosen the lock nut of the screw bearing at the worm end of the shaft, using wrench H-25937, and remove the screw bearing from the bracket. Slide the worm shaft into the screw bearing bracket sufficiently to clear the wing end of the shaft. Lift the wing end vertically and withdraw the shaft from the screw bearing bracket.

To replace the governor worm shaft, insert the worm end of the shaft into the screw bearing bracket sufficiently to permit inserting the wing end of the shaft into the cup bearing. Run the screw bearing into its bracket and cause the bearing to engage the worm end of the shaft. Carefully tighten the screw bearing leaving end play as stated in Section D-1. Securely tighten the lock nut of the screw bearing.

2.4 Impulse and Shunt Spring Bracket Assembly

The impulse spring and shunt springs are assembled on one mounting bracket which is fastened to the mounting base by two fillister-head screws. The bracket is fitted with two dowel pins for accurately locating the bracket on the mounting base.

2.5 Impulse Springs

To check the adjustments of the impulse springs, proceed as follows:

Hold the finger plate in an off-normal position, and pull the main (long) impulse spring slightly away from the middle (short) impulse spring. The middle impulse spring should have sufficient tension to rest firmly against the heavy stop spring.
Hold the finger plate sufficiently off-normal so that a low side of the impulse cam is parallel to the main impulse spring. The contact of the main impulse spring should rest against the contact of the middle impulse spring with contact pressure as specified in Section B-3.

Hold the finger plate sufficiently off-normal so that a low side of the impulse cam is parallel to the main impulse spring. The heavy stop spring should hold the impulse springs so that the clearance between the tip of the main spring and the low side of the cam is approximately the same as the separation between the spring contacts when the tip of the main spring is resting against the high side of the cam. The separation between the contacts may be determined by permitting the finger plate to restore slowly and watching the contacts open and close.

The impulse shorting arm of the shunt cam assembly should contact the bushing attached to the middle impulse spring during the last half revolution of the cam. This pressure should cause the tip of the main impulse to clear the high side of the impulse cam by a distance as specified in Section C-3, during the shorted impulse period.

If readjustment of the impulse springs is required, this may be accomplished using pliers 16290-7.

2.6 Shunt Springs

To check the adjustments of the shunt springs, proceed as follows:

Shunt springs should be so tensioned that when the dial returns to normal or is moved off normal, each spring will maintain contact with its adjacent spring during a travel of not less than the value specified in Section C-5. Contact separation for shunt springs in either the operated or normal position, as the case may be, should be within the limits specified in Section C-6.

The shunt arm should be aligned with the center of the bushing on the main shunt spring, with respect to end play of the main shaft, while the finger plate is in the normal position. Alignment should be such that the contact separation of the shunt springs is not less than the value specified in Section C-9, when the finger plate is pulled away (out) from the dial. If readjustment of the shunt springs is required, this may be accomplished using pliers 16290-7.

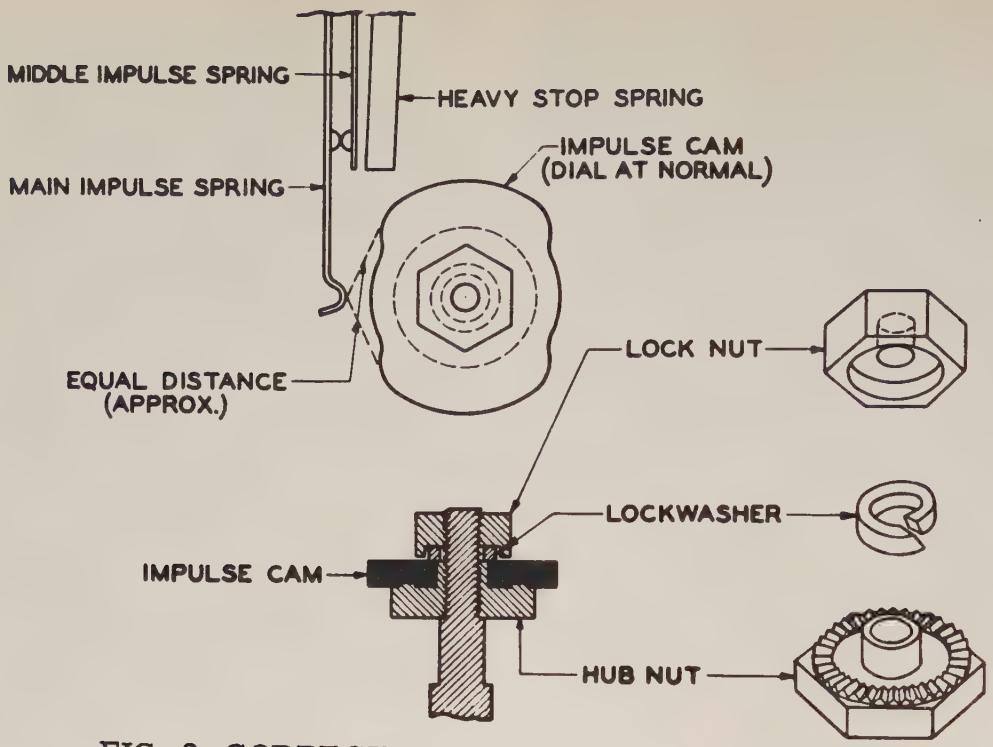



FIG. 2 CORRECT POSITION OF IMPULSE CAM

2.7 Impulse Cam

Figure 2 shows the correct position of the impulse cam (dial at normal). The design of the cam is such that the setting need be approximately only, and may be merely gauged by eye. Notice the radial knurl on top of the hub nut. The knurl teeth hold the impulse cam from slipping, when the assembly is properly tightened. A split-ring lockwasher fits into the cut-out portion underneath the lock nut, to keep the lock nut from loosening.

If the impulse cam accidently becomes loose or requires replacement proceed as follows:

Hold the hub net (under the impulse cam) with wrench H-25937, to prevent the nut from turning.

Loosen the lock nut (on top of the impulse cam) with socket wrench H-74958-1. The lock nut, lockwasher, and impulse cam may then be removed, or merely reset if the cam does not need replacement.

To reset the impulse cam, first tighten the hub nut using wrench H-25937. Make certain that the dial mechanism is in the normal position by rotating the dial off-normal, and allowing it to restore to normal, and then place the cam on the shaft in the position shown in Figure 2; that is, with the tip of the main impulse spring approximately equally distant from the two high sides of the cam. Place the lockwasher and lock nut over the cam and tighten in place. Hold the hub nut with wrench H-25937 while tightening the lock nut, to prevent possible damage to the governor worm and the worm gear.

Test by rotating the dial off-normal and allowing it to restore to normal. The impulse cam should come to rest in the position shown in Figure 2.

2.8 Finger Plate

To remove the finger plate, first remove the dial escutcheon card assembly as described in a previous section of this book, and then remove the locking screw and locking lever mounted on top of the finger plate. Lift the finger plate from the hub of the main shaft.

To re-assemble, place the finger plate over the hub of the main shaft with the blank section of the finger plate toward the finger stop. Center the locking lever over the main shaft hub with the tip of the lever located between the two small projections on the face of the finger plate, and tighten the locking screw. The locking lever should move freely around the collar of the locking screw.

2.9 Enameled Number Plate

To remove the enameled number plate, remove the dial escutcheon card assembly springs from the slots in the inner edge of the number plate. The escutcheon card tool or a small screw driver may be used to disengage the retaining springs.

To re-assemble, place the number plate in position with the slot in the outer rim engaging the finger stop. Lift the two retaining springs over the inner edge of the number plate and note that they are firmly seated in the associated slots.

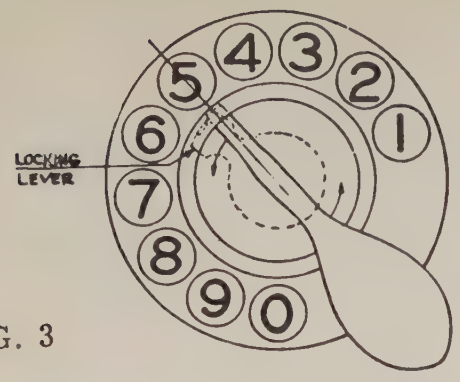



FIG. 3

TO UNLOCK ESCUTCHEON RING

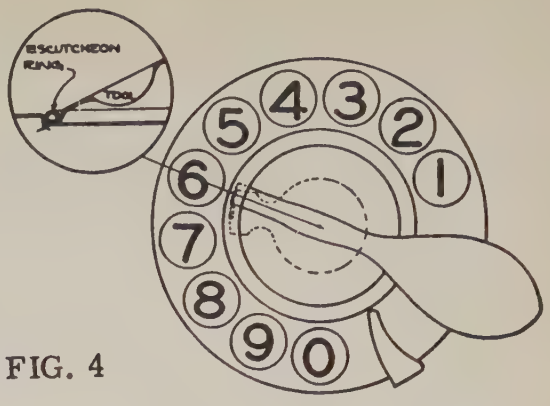



FIG. 4

ESCUTCHEON RING UNLOCKED

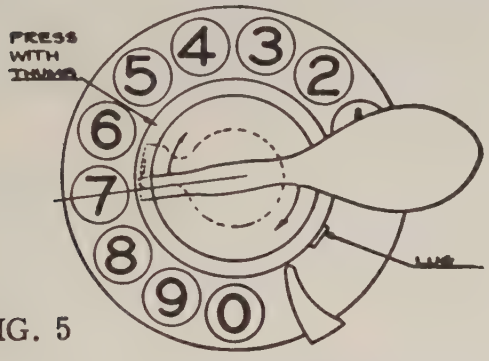



FIG. 5

TO LOCK ESCUTCHEON RING

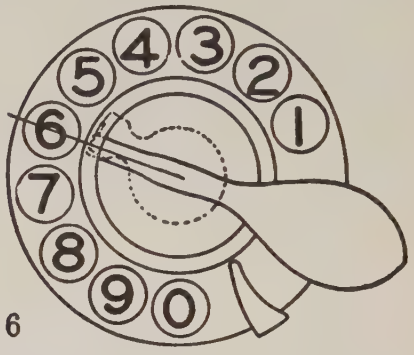



FIG. 6

ESCUTCHEON RING LOCKED

2.10 Finger Stop

To tighten the finger stop, remove the dial escutcheon card assembly, the finger plate and the enameled number plate. Thoroughly tighten the two fillister-head screws clamping the finger plate to the base plate.

The finger stop is fitted with two dowel pins for accurately locating the bracket on the base plate.

4. REMOVING DIAL ESCUTCHEON CARD

To remove the dial escutcheon card assembly, insert dial tool H-26917 (packed in one of the spare parts boxes) under the escutcheon ring opposite the digit "5" finger hole as shown in Figure 3. Press the tool down against the locking lever underneath the card and move the tool counter-clockwise to the digit "6" finger hole as shown in Figure 4. This unlocks the card assembly. With the tip of the tool, lift the escutcheon ring at the digit "6" finger hole and withdraw the card assembly.

The escutcheon ring, celluloid cover, dial card, and dial card clamping plate will come free as one assembly. The components may be released by turning the assembly face down and slightly rotating the notched clamping plate in a counter-clockwise direction, noting the relative position of the parts as they are removed.

In reassembling the components of the card assembly, place the celluloid cover in the escutcheon ring first so that it will protect the number card. The dial card is placed in the ring next, and last, the dial card

clamping plate is placed over the dial card. The clamping plate is turned in a clockwise direction to engage its tongue, locking the assembly.

To mount the card assembly on the dial, first check to see that the locking lever on the finger plate is pointed midway between digits "6" and "7". Then proceed to insert the small lug on the escutcheon ring into the slot located just above the finger stop, and press the assembly down into the finger plate.

Hold the assembly in place and insert the dial tool under the escutcheon ring opposite the digit "7" finger hole as shown in Figure 5. Press the tool down against the locking lever underneath the card and move the tool in a clockwise direction to the digit "6" finger holes, as shown in Figure 6. This locks the card in place. Remove the tool.

A. GENERAL

1. The dial shall meet the general requirements specified in A-100 which are applicable.
2. The finger plate shall not bind on the finger stop.
3. Not applicable.

B. IMPULSE SPRINGS

1. When not engaged by the impulse shorting arm, the middle impulse spring shall rest firmly against the heavy stop spring from its own tension.
2. Not applicable.
3. With the finger plate off normal, and the tip of the main impulse spring opposite a low side of the cam, the main impulse spring is adjusted at the factory to bear against the contact of the middle spring with minimum 25 grams, maximum 50 grams contact pressure.
4. With the finger plate off normal, and the tip of the main impulse spring opposite a low side of the cam, the heavy stop spring shall hold the middle and main impulse springs so as to make the separation between the main impulse spring and a low side of the impulse cam approximately the same as the space between contacts when the main impulse spring is resting against the high side of the cam.

C. MAIN SPRING AND SHUNT SPRINGS

1. The main spring shall have one to one and a third turns tension with the dial at normal.
2. The impulse shorting arm shall contact at the approximate center of the buffer on the middle impulse spring.
3. The impulse shorting arm should cause the main impulse spring to clear the cam by minimum .015", maximum .030" during the shorted impulse.
4. The impulse shorting arm should not cause the impulse springs to move until after the completion of the last pulse sent out.
5. Shunt springs should be tensioned so that as the dial returns to normal, or moves off normal, each spring will make contact with its adjacent spring while traveling thru a space of not less than .015".
6. Contact separation for shunt springs either in their operated or normal position shall be from .015" to .030".
7. Not applicable.
8. Not applicable.
9. The shunt spring operating cam width, shall be aligned within the width of the buffer on the operating shunt spring in the normal position, with respect to shaft end play. NOTE: Alignment shall be such that contact gap is min. .005" when dial finger plate is pulled out when at normal.

D. GOVERNOR

1. There shall be perceptible end play in the governor but this end play shall not exceed 1/64".
2. The governor wings shall be formed as nearly as possible alike.
3. The dial is adjusted at the factory by bending the governor wings, to operate at a speed of approximately ten impulses per second.

E. RATCHET

1. With the dial at normal, the pawl shall rest against its stop so as to give minimum .008", maximum .020" clearance between the shaft stop arm and its associated stop.

F. OPERATION

1. The dial shall operate freely as it restores to normal.

   NOTE: Tests for sticking shall be made as follows: Pull the "one" toward the finger stop until the pawl engages the next tooth of the ratchet and allows the dial to return to normal. Repeat once. Pull the "three" to the finger stop and release. Then pull the "six" and finally the "0". If the dial does not stick, the requirement is satisfactorily met.

# ELEMENTARY PRINCIPLES

NOTE: Below are presented certain Elementary Principles. In general the treatment is more detailed than that appearing in "Part A - General Principles". Some new matter will be found. In certain cases the excerpt may cite a figure which is not shown. In all cases a corresponding figure can be found in "Part A", look for it.

## 1.2 Explanation of Drawings

The drawings to be used in operating and maintaining the Strowger Telephone System are Equipment Drawings, Circuits, Circuit Explanations, Wiring Diagrams, Relay Adjustment Sheets, Standard Adjustments and Replacement Drawings.

"Equipment Drawings" are provided to illustrate the equipment and to show the method of mounting. Piece numbers for ordering replacement parts, and other information may be obtained from them.

"Circuit Drawings" illustrate the schematic layout of the equipment. "Wiring Diagrams" indicate the wiring of circuit components. All Circuits and Wiring Diagrams are prefixed with the letter "H" or "GH."

For each Circuit Drawing, there is also a "Circuit Explanation." This Circuit Explanation has the same numerical number as the circuit which it explains. In the case of a Circuit Explanation, the letter, "E" is substituted for the letter "H"; and "EGH" for "GH." The Circuit Explanations are provided so that the circuits may be more easily understood.

"Relay Adjustment Sheets" are provided for each circuit in order that proper adjustments may be made in the gauging and margining of relays, and special adjustments of mechanical parts as required. Relay Adjustment Sheets are designated with the prefix "AH" followed by the number of the circuit to which it applies. See page G-44.

"Standard Adjustments" are supplied for use in making general mechanical adjustments on the various units of apparatus. These Standard Adjustments are for reference only, as called for on the Relay Adjustment (AH) Sheets. The prefix letter of the Standard Adjustments is "A" or "GA."

"Replacement Drawings" (often called "Maintenance Drawings") identify the individual parts and also serve to show the construction of the various mechanisms. They are furnished to supplement the Equipment Drawings where deemed necessary or desirable. In general, the Replacement Drawings are to be used in conjunction with the Equipment Drawings, and are referred to when the piece numbers of detail parts not shown on the Equipment Drawings are required for ordering purposes. Replacement Drawings have the prefix "MD." See page G-45.

## 2. TELEPHONE SYSTEM

A telephone system consists of a group of telephones whose lines are so terminated at a central point that any two may be connected together. In automatic systems, connections are completed by remotely controlled switching mechanisms, instead of by human operators as in manual systems. The switching mechanisms are controlled by the person making the call, by means of a calling device (dial) on the telephone. When the dial is operated, it causes a series of interruptions (called impulses) in a current flowing in the line circuit. These impulses, the number of which correspond to the digits dialed, cause the automatic switches to operate.

The Strowger Telephone System under discussion consists of the following:

a. Line Station Equipment
   - Telephone Instruments (With Dials)
   - Extension Signals When Required

b. Automatic Switchboard Equipment
   - Switching Mechanisms
   - Miscellaneous Associated Equipment (Includes Ringing Machine, Alarm Signals, Testing Equipment, etc.)

c. Power Equipment
   - Power Panel
   - Motor-Generator Set
   - Storage Battery

d. Accessory Equipment
   - Attendant's Cabinet

The line station equipment consists of various types of telephones for mounting in both protected and exposed locations. In addition there are special loud-ringing signals for such telephone stations as require them.

The automatic switchboard includes the switching mechanisms necessary for setting up automatically the connection between two telephones, and certain miscellaneous equipment used in common by all switches. Under the latter head come ringing machines, alarm signals, testing equipment, and such items as control circuits for the switching mechanisms, start and stop circuits for the ringing machines, line disconnect keys, fuses, etc. The switchboard proper mounts all telephone switching mechanisms, control circuits, line disconnect keys, part of the testing equipment, and most of the supervisory alarm signals. The ringing machines are mounted externally, as are the common alarm signals.

The automatic switchboard equipment (including the ringing machines) operates on approximately 48 volts d-c as supplied by the motor-generator set and storage battery which are connected in parallel. Power to run the motor-generator set is obtained from the ship's 115-volt supply. A reserve supply of energy is maintained in the storage battery so that the telephone system will continue in operation should a ship's power failure occur.

## 3. TELEPHONE INSTRUMENT

A telephone instrument consists of a combination of the following component parts assembled into a complete working piece of apparatus:

a. Handset
   Transmitter Unit
   Receiver Unit
b. Dial
c. Cradle Switch
d. Ringer
e. Condensers
f. Induction Coil

The above-mentioned parts are suitably and compactly mounted in a manner depending upon whether the particular telephone instrument is to be used in a protected or an exposed location.

### 3.1 Handset

The handset consists of a conveniently shaped handle with two mounting cups--one for the transmitter and the other for the receiver. The mounting cups are at an angle with the handle to bring the transmitter at the proper distance from the lips for the average user when the receiver is centered on the ear. The transmitter and receiver are held in their mounting cups by means of an ear cap for the receiver and a mouthpiece for the transmitter. These retaining pieces screw onto the handset handle.

Both the transmitter and receiver units are of the capsule type. Connections from the cord conductors to the units are completed by means of contact spring clips which are contained in the mountings cups of the handset.

In order to prevent the possibility of inserting the transmitter into the receiver mounting cup and vice versa, the transmitter is made to fit only into the transmitter cup, and the receiver will fit only into the receiver cup.

### 3.2 Transmitter Unit

As mentioned above, the transmitter unit is of the capsule type. Inside the protective shell of the capsule are two fundamental elements which are: (1) diaphragm, and (2) carbon granule chamber. The diaphragm is set into vibration by the sound waves from the voice of the person talking. These mechanical movements of the diaphragm are transmitted to the carbon granules. When the carbon granules are compressed by an inward movement of the diaphragm, the electrical resistance is lowered and more current flows through the transmitter. Note that when the person is not talking and the diaphragm is at rest, a steady d-c current flows through the transmitter. This current is called "transmitter current" and is supplied by the common battery at the switchboard.

It is seen from the above, that as long as the diaphragm is vibrating from the speaker's voice, the resistance of the carbon granule chamber is constantly changing, which in turn causes the current through the transmitter to undulate accordingly. This undulating current, called the "voice current," is sent out on the telephone line, after being "boosted" as explained in Section 4.3.

### 3.3 Receiver Unit

The receiver unit is also of capsule type construction. The function of the receiver is opposite to that of the transmitter in that it converts the voice current received from the line back into sound waves.

The receiver is of the permanent magnet, polarized type. It consists essentially of a powerful bar magnet with two pole pieces to conduct the magnetic flux to the diaphragm. Voice currents, flowing through windings about the two pole pieces, set up magnetic fluxes which alternately add to and subtract from the magnetic flux of the permanent magnet, thus causing the receiver diaphragm to be attracted with alternately greater and less force. Accordingly, the diaphragm moves back and forth reproducing the original vibrations of the transmitter.

### 3.4 Dial

The dial enables the calling party to control the automatic switching mechanisms which establish the telephone connection. It has three principal functions which are: (1) to deliver impulses, (2) to short-circuit the parts of the telephone which introduce un-

necessary resistance in the dialing circuit, and (3) to prevent the dialed impulses from clicking in the receiver.

As shown in Figure A1, the dial consists chiefly of the following parts compactly mounted on a mounting plate: finger plate (with ten holes), number plate, speed control governor, impulse cam and springs, shunt cam and springs, and driving mechanism. These parts are so arranged that when the dial is operated, the line is opened and closed at a rate of approximately ten interruptions per second.

In operating the dial, the finger plate is turned in a clockwise direction. When restoring to normal under its own power, its speed is controlled in a counter-clockwise direction by the main spring and the governor assembly. While being turned in a clockwise direction, the tension of the main spring is increased to give sufficient tension to provide the power required to return the dial to normal.

The governor assembly consists of a worm gear shaft upon which are attached two wings each having a governor weight on the end. The rotary motion of the worm shaft causes the wings to attempt to fly outward and, due to centrifugal force this causes friction between the governor weights and the governor cup. The speed of the dial is therefore regulated by adjusting these wings to increase or decrease the amount of tension the governor weights exert on the inside surface of the cup.

The impulse springs are so mounted that the impulse cam, while revolving, will break and make the spring contacts a number of times corresponding to the digit dialed.

The shunt springs are used to shunt the receiver and transmitter circuits while the dial is operating or is in an off-normal position. The shunt springs are so mounted that, whenever the dial is in an off-normal position, they will be operated and when the dial again returns to normal, the shunt springs will be restored to normal. This shunting prevents the impulses from being heard in the receiver during dialing, and also prevents the variable resistance of the transmitter from affecting the character of the operating impulses.

### 3.5 Cradle Switch

The cradle switch (sometimes called plunger switch, switch hook, or Monophone switch) is an assembly of springs. These springs are used in completing and opening circuits. In a telephone set, it is desirable not to have both the talking apparatus and the signaling apparatus connected with the line at the same time. The cradle switch is therefore necessary in order that the signaling apparatus alone may be left operatively connected with the line while the telephone is not being used in the transmitting or reception of speech; and in order that the signaling apparatus may be cut out when the talking apparatus is brought into use.

The cradle switch is so arranged that removing or replacing the handset will bring about the circuit changes desired. The springs are designed to have sufficient tension to insure positive contact.

### 3.6 Ringer

The telephone ringers are of the polarized, untuned type, commonly known as "straight-line" ringers. These are suitable for use on both individual and "party lines." They are termed "untuned" since they will operate over a considerable range of frequencies.

As shown in Figure A2, the working parts of a polarized ringer include a permanent magnet, an electromagnet (a magnet which depends upon a flow of current through a coil to set up the magnetic flux in its soft-iron core,) a pivoted armature carrying a clapper rod and clapper, and a set of gongs. The electromagnet is in the form of a horseshoe magnet, with a coil winding around each leg. The armature (also soft-iron) is pivoted at its center so as to lie in front of the two poles of the electromagnet, but not quite completing the magnetic circuit.

The permanent magnet, which is usually in the shape of a broad "U," is located in such a position as to effect the cores of the electromagnet and also the armature. Thus, with no current flowing in the electromagnet coil, its cores and the armature are given a magnetic polarity as shown in Figure A2. Notice

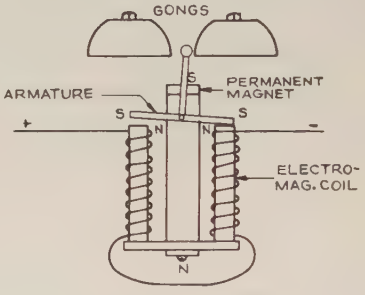


Fig. A2 Polarized Ringer

that the two free core ends are north (N) poles, while both ends of the armature are south (S) poles.

Now then, let us assume that a current is flowing through the electromagnet coil from positive to negative as shown in the diagram. The windings of the coil are in such a direction on each leg as to cause this current to produce N magnetic polarity at the free end of the core on the right, and S magnetic polarity at the free end of the core on the left. Since both core ends were already of N polarity, the right-hand pole is thus strengthened and the left-hand pole is weakened. This causes the armature to be attracted more by the right-hand pole than by the left-hand pole, and the clapper will strike the right-hand gong. A reversal of current produces opposite action, the left-hand gong being struck.

The actual ringing current is alternating current of approximately 20 cycles per second. This causes the armature to vibrate at the same frequency, producing the ringing signal.

In practice, small pieces of non-magnetic material are placed between the core ends and the armature to prevent actual contact and subsequent "sticking" due to residual magnetism. These are called "armature residuals."

A "biasing spring" is fitted to each ringer. This spring is fastened to one side of the armature. Its function is merely to hold the armature, and thus the clapper, to one side under tension to prevent the bell from tingling, during the dialing period.

### 3.7 Condensers

Two condensers are used in each telephone--one in the ringing circuit and one in the transmission circuit. The one in the ringing circuit is used to allow ringing current (alternating current) to pass through the ringer and to prevent direct current from flowing. The condenser in the transmission circuit is used to improve the transmission output characteristics of the telephone.

In telephone practice, the most commonly used condenser is the rolled type. This type of condenser consists of a roll of alternate layers of paper and aluminum foil sealed in a can. Each layer of foil is separated from the next layer by two layers of paper. The terminals of the assembly are slipped between the foil and the paper during the time the paper and foil are rolled. After the rolling is finished, the assembly is wax impregnated. This impregnating is necessary to cover the paper with a wax coating and at the same time to exclude all moisture and air bubbles in the rolled assembly. When the impregnation is completed, the assembly is inserted into a can where it is further sealed.

### 3.8 Induction Coil

The induction coil couples the transmitter and receiver units to the line, and also: (1) increases the output volume by "boosting" the voice current undulations developed by the transmitter, and (2) prevents, or decreases, "sidetone," which is the effect of a person hearing his own voice in his receiver while talking into the transmitter. For an explanation of how the induction coil operates, see the following section.

The induction coil consists of three windings wound on an iron laminated core. These windings are magnetically interlinked by the common magnetic circuit provided by the core. This type of coil serves as an autotransformer, which is simply a transformer in which part of the winding is common to both the primary (input) and the secondary (output) circuits. The core is made up of high permeability laminations --that is, it provides a low resistance path for the magnetic flux. It has a small airgap in the magnetic circuit to prevent saturation of the core by the direct current feeding the transmitter. This construction results in a very efficient coil in a small space.

### 4. TELEPHONE CIRCUIT

A diagram of a typical telephone circuit is shown in Figure A3. In this diagram are included the dialing, ringing, transmission, and receiving circuits. Booster and anti-sidetone features are included.

Notice in Figure A3 that the cradle switch is operated and the line circuit is in the dialing and talking position--the ringing circuit having been disconnected when the handset was removed from the cradle.

### 4.1 Dialing Circuit

The dialing circuit consists of the dial impulse springs, dial shunt springs, and the line wires. When the dial is operated, the transmitter, receiver, and induction coil are shunted out so that they will not interfere with the impulses sent out by the dial.

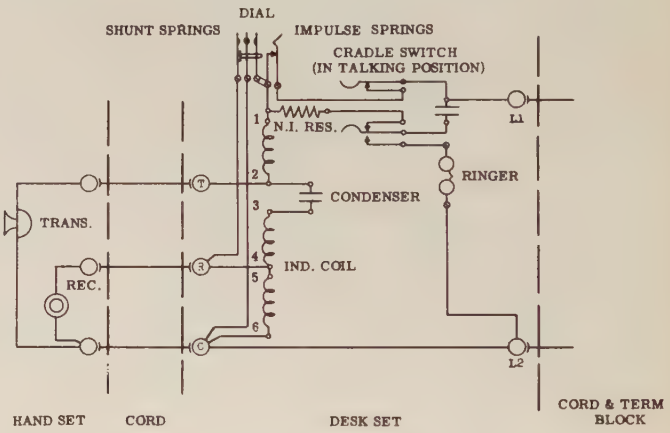



Fig. A3 Telephone Circuit

### 4.2 Ringing Circuit

The ringing circuit consists of the line springs of the cradle switch, the ringing condenser, and the ringer. As shown in the illustration the ringer circuit is open at the cradle switch. When the cradle switch is operated (handset removed), the condenser ordinarily in the ringer circuit is transformed to the impulsing springs of the dial to prevent excessive sparking at the contacts.

### 4.3 Transmission Circuit

This circuit includes the transmitter, receiver, induction coil, and condenser. Figure A4 illustrates the transmission circuit by means of a simplified diagram.

The units shown in Figure A4 are used in both the reception and transmission of speech. When they are used for transmission, the transmitter is used in converting sound waves into electrical undulations, and when used for reception, the receiver converts

electrical undulations into audible sound waves. In voice transmission, the 3-4 and 6-5 windings of the induction coil are used as the primary of the coil. In voice reception, winding 1-2 is used as the primary.

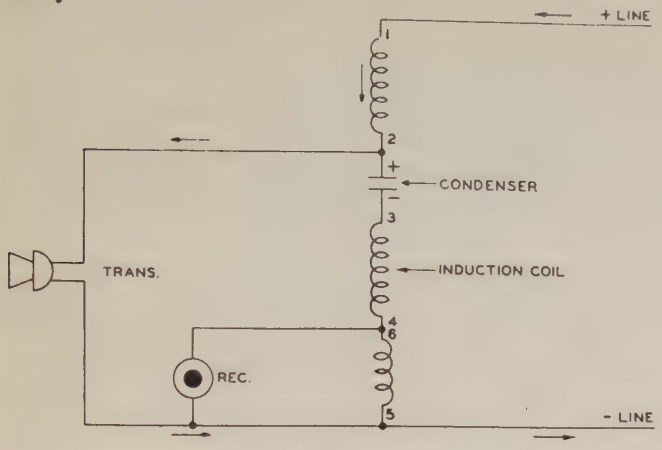



Fig. A4 Transmission Circuit

The booster feature consists of accentuating (boosting) the voice current undulations produced directly in the line by the transmitter. This is accomplished through use of the induction coil (acting in conjunction with the condenser).

The anti-sidetone feature consists of preventing the voice currents set up by a transmitter from flowing through the receiver of the same telephone instrument. This, like the booster feature, is accomplished through the use of the induction coil.

During speech transmission in a circuit of this type, the two distinct circuits which must be kept in mind are: (1) the main talking circuit which includes the positive line, winding 1-2 of the induction coil, transmitter, and the negative line; and (2) the local talking circuit, purely local to the telephone which includes the transmitter, condenser, and windings 3-4 and 6-5 of the induction coil. At this moment, it is advisable to point out that the induction coil used in this circuit consists of three windings, all of which are wound on the same core and connected in series as indicated in the circuit. The series combination of the three windings is, in effect, an autotransformer, that is, the primary winding is the winding or windings in which the primary circuit is flowing, and the secondary is the series combination of all three windings. The 1-2 winding has the most turns of wire; the 3-4 winding is made up of less turns than the 1-2 winding; and the 6-5 winding, which may be called the anti-sidetone winding, has a smaller number of turns than the 3-4 winding and is connected in series with 3-4 but opposed to it. A resistance is built into the 6-5 winding and is adjusted for minimum potential across the terminals of this winding when the telephone is connected through a loop of average length to another telephone. Thus sidetone in the receiver is greatly reduced by the close balance between the induction coil windings.

In Figure A4, the direct current path through the telephone is from the positive line, through the 1-2 winding of the induction coil, through the transmitter to the negative line as indicated by the solid arrows. Since the condenser is connected across the transmitter in series with the 3-4 and 6-5 windings of the induction coil, its plates will acquire a positive and negative charge as designated. When talking into the transmitter, it will be readily seen that two sets of current undulations are set up, namely: (1) those directly produced in the line due to the variations in the resistance of the transmitter, and (2) those produced in the local talking circuit by the charging and discharging of the condenser due to the varying potential drop across the transmitter.

The local talking circuit current undulations will be best understood if it be kept in mind that the condenser is connected across the transmitter, directly on one side and through the 3-4 and 6-5 windings on the other side. From the above connections it is evident that the potential difference across the condenser will be varied by potential variations across the transmitter terminals. Alternating currents will then flow in the local circuit as the condenser adjusts its charge to the varying difference of potential across the transmitter and across its own terminals.

The resultant alternating currents flowing in the 3-4 and 6-5 windings (the primary winding in this case) will induce currents in winding 1-2 of the coil. The induced current is equal to the difference between the current induced by 3-4 and the current induced by 6-5 because the induced currents of the two windings are in opposite directions. This induced current in winding 1-2 reinforces the voice current directly delivered to the line by the transmitter. The electromotive force induced into the 6-5 winding from the 1-2 and the 3-4 windings is of such value and direction, that it tends to make resultant electromotive force across 6-5 equal to zero, so that there is no fall of potential across the receiver and the circuit is therefore anti-sidetone.

The inductive balance required for complete neutrality with respect to sidetone is dependent on the relative impedances of the local circuit containing the induction coil windings 3-4 and 6-5; and the line circuit containing the winding 1-2. Since the line conditions vary with different lengths of line, the characteristic impedance of a typical line is used as a standard, and the impedance of the local circuit is arranged to balance it. As the line departs from this, sidetone will tend to increase. However, this tendency will be offset by the decreases in sidetone due to reduction in current supply to the transmitter with increased loop resistance.

### 4.4 Receiving Circuit

During the reception of speech, the 1-2 winding of the induction coil acts as the primary, and the windings 3-4 and 6-5, which were the primary become the secondary. The voice currents are received via the main talking circuit, which includes the positive line,

winding 1-2 of the induction coil, transmitter, and the negative line.

The currents flowing in the main talking circuit induce currents into the local talking circuit consisting of the condenser, 3-4 winding, receiver, and transmitter. Only a small portion is induced into the 6-5 winding; most of the current being induced into the 3-4 winding. The reason for this is that the potential induced into the 6-5 winding is of such value and direction that it opposes the current that would flow through this winding due to the potential across the receiver,thus reducing the current through the 6-5 winding to a very small value.

## 5. FUNCTIONS OF THE AUTOMATIC SWITCHBOARD

The automatic switchboard is the "switching center" of the Strowger Telephone System. Mounted thereon are the switch mechanisms which automatically:

a. Locate a station desiring to make a call.

b. Respond to dial pulses and extend the calling station to the called station.

c. Ring the called station, selecting it from among those on a party line, if necessary. This is called the "selective ringing" feature.

d. Supply various tones, such as dial tone, busy tone, ring-back tone, etc., as required.

e. Provide "hunt - the - not - busy - line" service where required. This is a feature whereby if the lowest numbered of a consecutively numbered group of line stations is called, the switchboard will automatically connect the calling line station to the lowest numbered idle line station of such group, returning busy tone only if all line stations of the group are busy.

f. Provide "executive cut-in" service to line stations as specified. This is a feature whereby such line stations complete their connection to any line station they may call, regardless of whether that line station is busy or not.

g. Disconnect the calling and called stations at the completion of the conversation.

h. Perform certain other operations in connection with telephone service.

## 8. MECHANICS OF THE STROWGER SWITCH

### 8.3 Switch Mechanism

The switch mechanism is the mechanical arrangement which moves the shaft and wiper assembly. It consists of those parts which are necessary to move the shaft and wiper assembly in both a vertical and a rotary direction. It also has provision for causing the shaft and wiper assembly to return to its normal position. A photograph of the basic switch mechanism is shown in Figure A14.

As shown in Figure A14, the parts which co-operate in giving one kind of motion to the shaft have come to be named after that motion. In the photograph, the mechanical relation of the operating parts is not clear because some of the parts are hidden from view. To illustrate clearly the relationship of the operating parts, the diagrams, Figures A15 to A18, inclusive, are provided.

The first view, Figure A15, in the series shows how all of the other views are co-ordinated into one structure. Also in the first view are indicated the wipers, and the bank contacts with which the wipers are brought into engagement by the vertical and rotary movements of the shaft. The parts involved in a particular motion are shown in each of the three views of Figures A16, A17, and A18.

From the series of illustrations, it will be readily seen that the parts which co-operate in giving one kind of motion to the shaft are named after the motion.

### 8.31 Shaft and Hub

The shaft, on which the wipers are fastened and by which they are controlled, is made up of a piece of drill rod on which is pressed and pinned a hub, (see Figures A14 and A15). Fastened to the upper end of the shaft is a shaft spring assembly. Below the spring assembly is the normal stop pin which rests against the shaft spring bracket when the shaft is at normal to prevent the shaft from swinging too far to the left due to the torque exerted on the shaft by the shaft spring. When the shaft is in the normal position, the normal stop pin rests on an arm which causes the off-normal springs (ONS) to operate. The weight of the shaft rests on the normal stop pin clamp which strikes on the upper shaft bearing when the shaft is at normal. Two bearings, one at the top and one at the bottom of the switch frame, guide the shaft. Below the shaft hub is a cam in the shape of a sleeve which clamps tightly on the shaft and serves to operate the cam springs during the rotary operation of the shaft.

The hub of the shaft consists of two sections, the upper section being the vertical ratchet and the lower section the rotary ratchet. The vertical ratchet consists of ten horizontal teeth cut into the upper part of the hub. The rotary ratchet consists of eighteen vertical teeth cut into the lower part of the hub. The vertical ratchet is used for lifting the shaft, and the rotary ratchet for rotating the shaft.

Certain dogs and detents are associated with the ratchets. The dogs engage teeth in the ratchets when the ratchets are moved off normal and hold the rat-

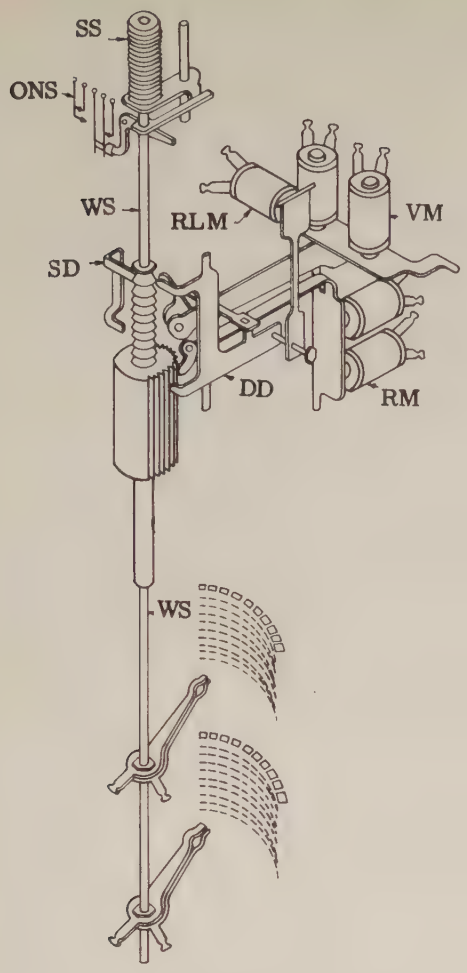



Fig. A15 Vertical, Rotary and Release Principles

chets in the position last operated. Two such dogs are used--the stationary dog and the double dog. The stationary dog is, as implied by the name, stationary and does not move. It is an auxiliary to the double dog and is used to hold the vertical ratchet elevated when the shaft is rotated. The double dog is used for two purposes which are: (1) to prevent the shaft from falling while the shaft is being stepped vertically, and (2) to prevent the shaft from returning to normal while the shaft is being rotated and, when the rotation is completed, hold the rotary shaft in the last operated position.

8.32 Vertical Motion

The vertical movement of the shaft is accomplished by relaying the impulses from the dial to the vertical magnet, VM in Figure A16. With each energization of the vertical magnet, the vertical pawl of the vertical armature presses upwards against the teeth of the upper part of the hub and causes the shaft to lift the wipers one bank level; and when the first series of impulses has ceased, the wipers are in line with the desired bank level. With each de-energization of the vertical magnet, the vertical pawl is withdrawn from the ratchet of the hub and the vertical tooth of the double dog engages a tooth of the vertical ratchet to retain the shaft in the elevated position.

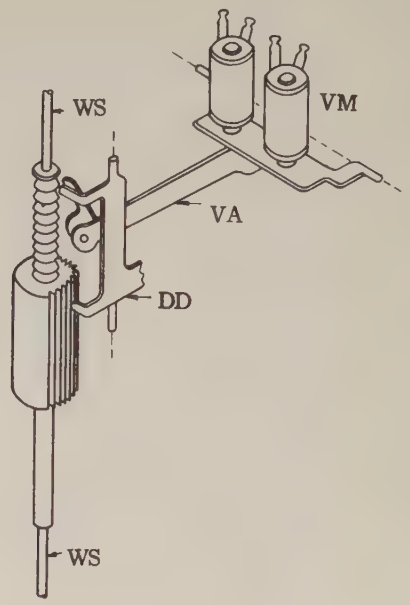



Fig. A16 Vertical Movement of Shaft

The double dog is normally held clear of the shaft ratchets by means of a flat spring called the "release link." This spring extends from beneath the vertical armature lever of the double dog where it hooks over a lug of the double dog. With the first energization of the vertical magnet, a finger on the underside of the vertical armature lifts the spring from the hub, thus causing the double dog to engage the ratchet teeth of the hub as previously explained.

A groove in the left side of the vertical teeth allows the shaft to pass by the stationary dog during the vertical movement of the shaft. The stationary dog supports the weight of the shaft during the rotary motion. On the underside of each vertical tooth is a "bump." and these bumps are engaged by the vertical tip of the double dog during vertical stepping. The stationary dog is adjusted so that as the "bump" on the vertical tooth moves off the vertical tip of the double dog (on the first rotary step), the edge of that vertical tooth (at the groove) passes on to the stationary dog without raising the shaft or allowing it to drop perceptibly. Therefore, as soon as the bump on the underside of the vertical tooth has left the vertical tip of the double dog, there is a clearance between the double dog and the vertical tooth, and the stationary dog supports the weight of the shaft.

8.33 Rotary Motion

In the rotary movement, the shaft is rotated to the proper contacts in the selected bank level. The parts used in this movement are shown in Figure A17.

With each energization of the rotary magnet, the rotary pawl engages a tooth in the lower part of the hub and causes the shaft to rotate the wipers one step. Each time the rotary magnet is de-energized, the rotary pawl is withdrawn from the ratchet of the shaft and the rotary tooth of the double dog (bottom tooth) engages a tooth of the shaft ratchet for retaining the shaft in the rotated position.

With the rotary armature fully operated, the shaft is forced around just far enough to cause the rotary tip of the double dog to drop into a rotary notch in the shaft hub. While the rotary armature is at normal, the armature rests against the rotary stop pin. This

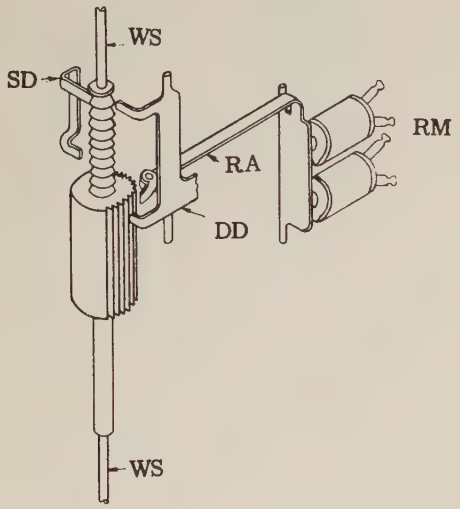



Fig. A17 Rotary Movement of Shaft

pin is adjusted so that the pawl of the rotary armature just clears the hub of the shaft as the shaft is being stepped vertically or released. The flat piece of clock spring fastened to the armature and bearing against an adjusting screw in the frame, gives the necessary tension to restore the rotary armature to its normal position. The vertical, rotary, and release magnet coils each have a brass cap over the coil core end to cause the armatures to release quickly after the coil circuits are opened and thus allow quick positive operation of the armature.

8.34 Release Action

The release of a Strowger switch is accomplished through the energization of the release magnet. Figure A18 illustrates how the switch is released and restored to its normal position. The release magnet is located in front of the vertical magnet. When the release magnet is energized, the stud of the release armature presses against the double dog, and causes it to withdraw the vertical and rotary teeth from the ratchets of the shaft. A flat spring now hooks over the projecting lug of the double dog and retains the double dog in the normal position out of engagement with the ratchets of the shaft.

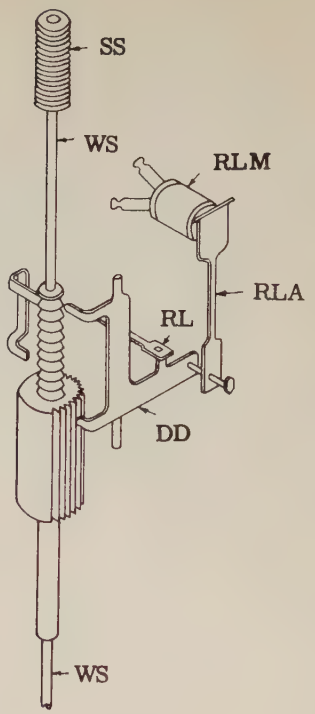



Fig. A18 Release Action of Shaft

When the double dog is out of engagement with the shaft ratchets, a helical spring, located at the upper end of the shaft, causes the shaft and wipers to rotate back and clear the bank. While the shaft is being returned to its rotary starting position, the shaft is prevented from dropping by the stationary dog, but when the dog finds the slot in the ratchet, gravity causes the shaft to drop to the normal position.

8.4 Spring Assemblies

Strowger switches are equipped with spring assemblies as needed. These vary depending on whether the switch is a finder, connector, or selector (consult the circuit drawings of the switch at hand in order to see first which springs are present). The following are the spring assemblies usually encountered.

(a) Off-Normal Springs

Near the top of the switch mechanism frame, and on the left-hand side, are the off-normal springs (see Figure A13). These are generally referred to as the V.O.N. (vertical off-normal) springs; or S.V.O.N. (Strowger vertical off-normal) springs. These springs are in one position when the switch shaft is at normal. When the shaft is lifted one step, the normal pin is lifted clear of the off-normal spring lever, and the moving springs restore against their associated back contact springs. The moving springs are adjusted with very stiff tension to assure good contact, but are not made so stiff that they prevent the shaft from restoring to normal. A set of vertical off-normal springs is mounted on all types of Strowger switches.

Some Strowger switches are equipped with a set of rotary off-normal springs (R.O.N. or S.R.O.N.). However, these are merely cam springs (see next paragraph) adjusted to operate on the first rotary step, instead of the eleventh rotary step.

(b) Cam Springs

The cam springs are located on the lower right-hand side of the switch mechanism frame as shown in Figure A13. These springs are operated by means of the cam clamped onto the lower part of the shaft just below the hub. The shaft cam is usually adjusted to operate the springs on the eleventh rotary step, the poir at which the wipers pass off the last contact on the level.

(c) Interrupter Springs

Both vertical and rotary interrupter spring assemblies may be seen in Figure A13. These assemblies usually consist of only two springs each. The moving spring of the assembly is operated by an arm which is part of the armature of the magnet with which the spring assembly is associated.

Interrupter springs are used in furnishing the impulses for automatic stepping of Strowger switches. Thus, a finder switch will have both vertical and rotary interrupter springs; a selector switch rotary interrupter springs (for trunk-hunting on the dialed level). A connector switch will also have rotary interrupter springs (for hunt-the-not-busy-line service).

Interrupter springs are not identified by any particular title on circuit drawings. However, the assembly may be identified by noting its location; it is always shown in front of the magnet with which it is associated. The magnet will be designated either VERT. (vertical) or ROT. (rotary).

(d) Release-Signal Springs

Strowger switches are generally equipped with a set of release-signal springs as illustrated in Figure A13. These springs are actuated by a lever which is attached to the release armature.

In the case of connector switches which have minor switches mounted on them, the release-signal circuit function is usually handled by the minor switch spring assembly, and in such cases the release-signal springs will not be present on the Strowger switch release armature.

8.5 Switch Jacks

A jack strip contains from 16 to 32 jack springs insulated one from the other and arranged so that they make contact with jack clips when the switch is jacked into place. The jack strip is fastened to the rear of the base below the "fanning strip." In cases where it is necessary to have more than 32 jacks to the base, two jack strips are mounted on the base, one beneath the other. The wires are connected to these jacks after being fanned out on the fanning strip provided. All circuits leaving or entering this switch pass through the jacks so that it is not necessary to disconnect any wires when removing the switch from its mounting place.

Below the jack strip is an opening in the base through which the rotary magnet adjusting screws are reached when adjustment is necessary. This opening is normally covered by a plate to exclude dust from the switch mechanism.

8.6 Relay Mountings

The relays are mounted above the switch mechanism in two vertical rows with their spring assemblies toward the sides of the switch. Each relay is held in place by two mounting screws extending through the base from the rear. The relays are insulated from the base by insulators.

The relay coil terminals and spring terminals extend through the openings provided in the base so that the necessary wires are all connected and run in on the rear of the switch mounting base. A rear dust cover is provided to protect the wiring.

8.7 Test Jack

Strowger switches are provided with test jacks as needed. These are mounted on the underside of the horizontal part of the mounting base, in front of the banks, and usually on the right-hand side.

The test jacks are used in testing switches for proper operation, or for "monitoring" calls. Such jacks are usually found on selectors and connectors (a jack is not present in Figure A13, which is a finder switch).

8.8 Busy Key

Whenever it is desired to "busy out" a defective switch, and sometimes for testing purposes, the busy key of that switch is operated. This busy key is also located on the underside of the horizontal part of the mounting base, but usually on the left-hand side; that is, on the side opposite the test jack.

Here again, busy keys are usually found on selectors and connectors. A finder switch will automatically be busied out when the busy key on the switch to which it is connected is operated.

9. MECHANICS OF THE MINOR SWITCH

A minor switch consists simply of a bank assembly wiper assembly, and the mechanism required to move the wipers. The switch has rotary motion only.

As shown in Figure A19, the bank assembly has ten sets of contacts arranged in an arc similar to one level of a Strowger switch bank. Actually, the bank assembly on a minor switch may be one, two, or more levels deep depending on the circuit requirements. Each level has associated with it one pair of wiper

springs. Usually, the upper surface of each level consists of ten individual contacts, while the bottom surface is a solid segment (called a contact common). The pair of wiper springs merely closes the circuit from the particular top contact upon which it stops, to the contact common.

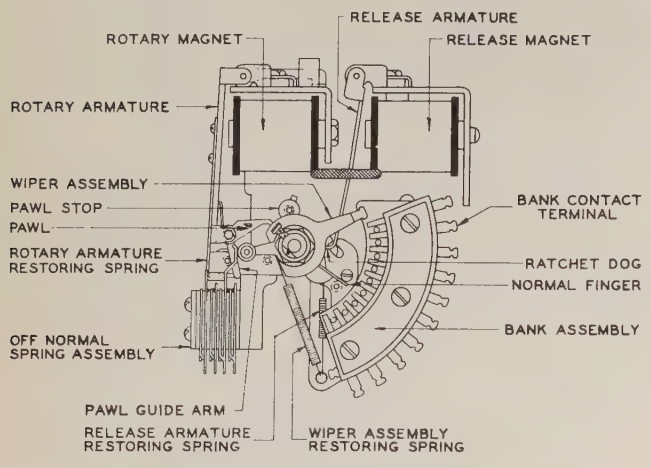



Fig. A19 Minor Switch

To control the movement of the wiper assembly, two electromagnets are furnished. One is for rotary stepping and one for release. The armature of the rotary magnet carries a pawl which operates the rotary mechanism. When dial impulses energize the magnet its armature is attracted, and the pawl engages one of the teeth on a ratchet wheel, causing the ratchet to turn on its axis. The wiper pairs are rigidly assembled to this ratchet and thus step with it. The number of steps corresponds to the digit dialed. A flat steel spring attached to the rotary armature provides restoring tension for the armature after each energization of the rotary magnet.

The ratchet dog, which is merely the hooked end of the release magnet armature, is controlled by the release armature restoring spring and the magnet. It engages the teeth on the ratchet wheel and retains the wipers on the contacts to which they have been stepped by the rotary mechanism. As the wipers step, the wiper assembly restoring spring, which is attached to the wiper assembly, increases its tension. This tension restores the wipers to their normal position (one step off the first contact) as soon as the release magnet operates and disengages the ratchet dog from the ratchet wheel.

Minor switches are equipped with a spring assembly called the M.S.O.N. (minor switch off-normal) springs. These are actuated on the first rotary step and usually serve two functions. The first of these is concerned with the release circuit of the minor switch itself. The second function is concerned with the circuit to the release-signal of the connector switch with which the minor switch is associated. In regard to the latter function, both the Strowger switch and the minor switch have to properly restore to their normal positions, or else the connector release signal will operate to give a warning.

## 10. MECHANICS OF THE RELAY

A relay is an electromagnetic device used to open and close electrical circuits. As shown in Figure A20, the device consists of a coil, an armature, and a set of springs mounted on a heelpiece. The particular form of relay illustrated in the figure is known as a "horizontal" relay--the great majority of the relays used in the Ship's Service Telephone System equipment are of this type.

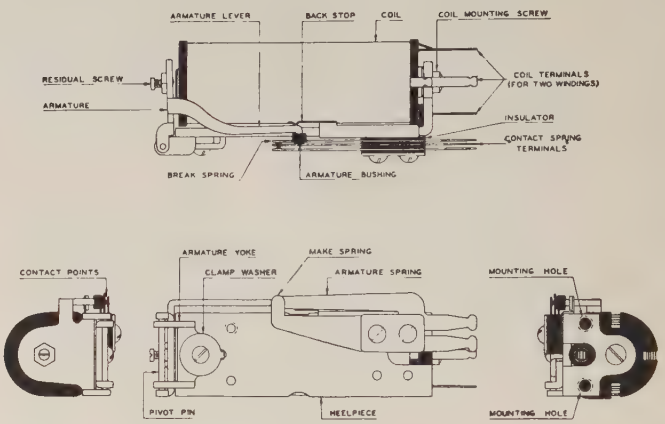



Fig. A20 Relay

When current is sent through the coil of a relay, a magnetic field is set up around the coil. The magnetic circuit consists of the core of the coil, the heelpiece, and the armature. The magnetic lines of force are sufficiently powerful to attract the armature toward the core of the coil. When the armature is drawn toward the coil, the armature lever operates the spring assembly. When the current ceases to flow, the armature is released and the spring assembly returns to its normal position.

### 10.1 Coil

The coil consists of an iron core around which the wire is wound. Fastened tightly near each end of the iron core is an insulating washer which holds the wire on the core. The wires wound on the core are connected to the coil terminals at the rear end of the coil. Notice that the coil often consists of two or more distinct windings.

### 10.2 Heelpiece

The heelpiece, like the core of the coil, is made of iron. This heelpiece is "L" shaped so that the coil, the armature, and the spring assembly may be secured to it as indicated in Figure A20. By means of an iron screw, the coil is fastened to the rear end of the heelpiece so that the coil core and heelpiece are in contact. Tapped holes are provided on the rear end of the heelpiece so that the relay may be fastened to a mounting plate.

### 10.3 Armature

The armature assembly consists of an armature, a pivot pin, and a yoke. The armature is pivoted at the open end of the yoke by the pivot pin. The assembly is fastened to the front end of the heelpiece by a screw which secures the armature yoke to the heelpiece. The armature yoke and the pivot pin are made of non-magnetic metal for if they were of magnetic metal, they would become a part of the magnetic circuit and the armature would bind when operated. The armature is made of magnetic metal which is zinc plated.

In the center of the armature is inserted a metallic residual screw, also non-magnetic, and a lock nut. The screw is used to adjust the space between the armature and the coil core when the relay armature is in its operated position. The residual screw is so called because this screw aids in preventing residual magnetism from holding the armature in an operated position when the circuit to the coils of the relay is opened.

The armature lever is that part of the armature which operates the spring assembly. On the end of the armature lever is an insulating bushing which insulates the armature lever from the spring with which it makes direct contact. A back stop is provided against which the armature lever rests when in its non-operated position.

### 10.4 Spring Assembly

The spring assembly is made up of a number of metallic springs which are insulated one from the other, and from the heelpiece. The rear ends of these springs are specially formed so as to provide terminating points for the circuit leads. Each spring has one or more contacts of precious metal by means of which a connection is made to some other spring.

Relay springs are assembled in various combinations in accordance with circuit requirements. As shown in Figure A21 there are three types of springs. Note that all of the armature springs are moved as a unit when the armature bushing (on the end of the armature lever) pushes against the first armature spring. The motion is transmitted to the succeeding armature springs by virtue of the spring bushings.

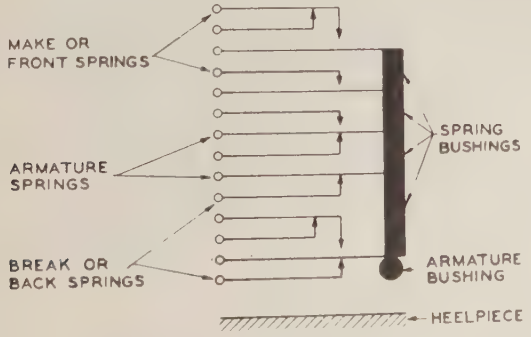



Fig. A21 Types of Relay Springs

Six different spring assemblies for horizontal relays are shown in schematic form in Figure A22. Assem. A consists of a break contact and an armature spring and is called a break assembly. Assem. B consists of an armature spring and make contact and is called a make assembly. Assem. C consists of a break spring, an armature spring, and a make spring and is called a break-make assembly. Assem. D consists of an armature spring, a break spring, and a make spring, and is called a make-before-break assembly. All other assemblies are made up by combining these basic spring groups in different ways. Assem. E consists of a break-make, a break and a make combination. Assem. F consists of a break-make-before-break, a break-make, a break, and a make combination.

### 10.5 Spring Adjustments

Relay spring adjustments comprise two main operations which are: (1) spring gauging, and (2) margining. The purpose of all adjustments is to insure positive relay armature operation, and also to provide adequate pressure between the pairs of spring contacts in order to insure that the electrical circuits are properly closed.

"Spring gauging" is merely the act of adjusting (by bending) the springs so that the armature springs exert pressure against the break contacts when the relay is in the non-operated position, and against the make contacts when in the operated position. In order to determine when the various springs are correctly tensioned, simple measurements are made as explained in the following paragraph. However, it is pointed out now that relays are correctly adjusted when they leave the factory, and very little readjusting is required.

The decimal values which appear between the springs of the various assemblies in Figure A22 record the air gap in inches that must exist between the residual screw in the armature (see Figure A20) and the coil core as the springs just break or make contact. The air gap is measured by inserting thickness gauges between the residual and the coil core. For example, the springs in Assembly A (Fig. A22) must be adjusted to just break contact, as judged visually, with a .006" air gap between the residual screw and coil core. The value of .010" outside the springs in Assembly B (Figure A22) is called a stroke value. This stroke value is the normal armature air gap; that is, the air gap with the armature in an unoperated position, and is met by adjusting the armature back stop (see Figure A20). Stroke values are necessary only for relays which do not have a break contact as the first spring in the assembly. The contacts in Assembly B must be adjusted to just make contact with a .006" armature air gap. The values associated with the springs in the other assemblies will be understood to control the operation of the springs with respect to the armature air gap as described for Assemblies A and B.

In addition to the mechanical adjustment requirements controlling spring operation, a requirement is always stated which limits the amount the residual screw

protrudes through the armature. The adjustment of this residual screw varies the air gap between the armature and coil core with the armature operated and the stated requirement is met by adjusting the screw until this air gap agrees with the requirement.

"Margining" is the checking of a relay for satisfactory operation of the armature between specified electrical limits; that is, between two values of current, one of which is called the operate (0) value and the other the non-operate (NO) value. For testing purposes, the current may be determined practically by one of two methods which are: (1) measurement with a milliammeter, and (2) application of a known voltage to the relay coil with a specified resistance connected in series with it.

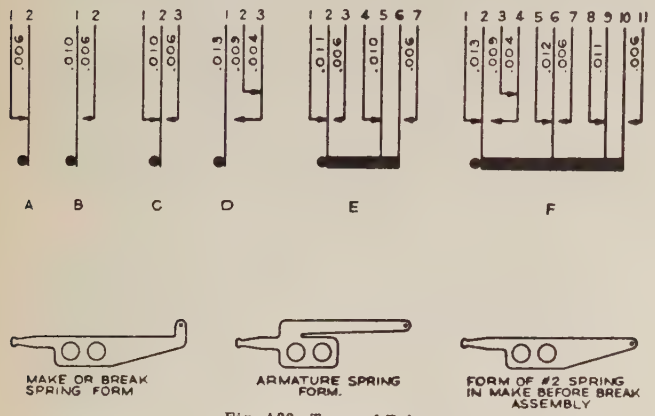



Fig. A22 Types of Relay Spring Assemblies

Actually, margining is a method of measuring the total resistance (or load) offered to the operation of the armature due to the tension in the springs. Thus, the springs must be adjusted to provide sufficient load when the specified non-operate current is flowing in the relay coil so that the armature cannot operate. This spring tension is utilized in exerting contact pressure between the armature springs and the back contact springs. However, the springs must not be adjusted to provide too great an armature load, because the specified operate current must cause complete operation of the relay. In practice it will be found that in general when the spring gauging is correct, the margining tests will be met without any further adjustment.

## 10.6 Slow-Acting Relays

Many circuit conditions require relays that are slow-acting. For example, certain relays in Strowger switches must remain operated even though their circuits are repeatedly interrupted. The interruptions to such relay circuits are commonly caused by dial impulses.

There are two general types of slow-acting relays; namely: (1) slow-to-operate (S.O.), and (2) slow-to-release (S.R.). The relays cited in the preceding paragraph would obviously be of the slow-to-release type.

In both the slow-to-operate relay and the slow-to-release relay, the slow-acting feature is accomplished by placing a copper collar (slug), or a copper sleeve, around the coil core in the correct position to obtain the desired result. The effect of the copper upon the operation of the relay will be made clear by a discussion of a slow-to-operate relay in the next paragraph.

A slow-to-operate relay has a copper collar placed around the armature end of the coil core. Consider the coil of the relay as the primary of a transformer and the copper collar as a short-circuited winding consisting of a single turn of wire having very low resistance. When the voltage is first applied to the primary winding, the current tends to build up and establish a magnetic field through the relay core. This magnetic field will be of changing value during the interval that the current in the coil is building up from zero to its steady state value. The instant the changing magnetic lines of force cut through the copper collar, a voltage is induced in the collar causing a current to flow in it. This current is in such a direction that the magnetic field which it sets up opposes the field being built up in the core by the current in the relay coil, and thus delays the attracting of the relay armature to the core. Gradually, as the current in the relay coil approaches its steady state value, the current induced in the copper collar becomes less and less, and the magnetic field through the relay core builds up to a strength sufficient to attract the relay armature. Notice here that when the circuit to the relay coil is opened, the process just explained will act in reverse, and the effect of the copper collar will be to cause a momentary delay in the release of the armature. Thus, the slow-to-operate relay is also slow-to-release.

When it is desired to have a relay which is slow-to-release, and yet quick to operate, this is accomplished by providing either a copper collar at the heelpiece end of the core, or a copper sleeve along the entire length of the core underneath the coil winding. To understand why the collar at the heelpiece end of the core does not appreciably affect the operating time of a relay, consider for a moment that the magnetic flux which actually attracts the armature is that part of the flux which passes from the relay core, across the air gap, and into the armature. Therefore, when the copper collar is placed at the heelpiece end of the core, the effect of the magnetic flux due to the current induced in the collar is negligible as far as opposing the flux at the armature end of the core. Sufficient flux finds its way unopposed across the air gap to quickly attract the armature to the core. On the other hand, once the relay has operated, the air gap between the core and the armature no longer exists, and a copper collar anywhere along the closed magnetic circuit will act to oppose any change in that circuit. This the heelpiece-end collar does, to give the relay its slow-to-release characteristics, but without appreciably affecting its operating time.

In the case of the slow-to-release relay with a copper sleeve, the sleeve acts as a single-short circuited

turn in the same manner as described for the copper collar. Moreover, the sleeve results in a saving of copper, however, the operating time of the relay is affected more than when a heel-piece-end collar is used. Thus, the copper sleeve finds wide use for those cases requiring a slow-to-release relay, but where the operating time is not critical.

10.7 Miscellaneous Special Relays

A few special relays are encountered in the Ship's Service Telephone System equipment. Most of these are merely minor variations of the standard horizontal relay which has just been described at length. Some of the most common of these special relays are as follows:

(a) Short-Lever Armature Relay

Where release delay is required greater than that provided by use of a heelpiece-end copper collar, or a copper sleeve, a special armature construction is employed, in which the effective length of the armature is approximately the same as the length of the contact spring arm. Briefly, this "short-lever" (or 1-to-1 ratio) armature eliminates the mechanical advantage (approximately 2.75 to 1) of the contact springs acting on the standard armature and tending to restore it to normal. Lacking this mechanical advantage, the springs are unable to restore the armature until the magnetic field has died down to a considerably lower value. This results in a longer release delay.

(b) Double Armature Relay

A double armature relay is equipped with an armature which has two lever arms, one on each side, to operate two sets of contact springs. Each of the two sets of springs is called a "spring pile-up."

"Spring combinations" is the term applied to the entire spring assembly of either a single or double armature relay.

(c) Two-Step Relay

The line relays constitute an example of a two-step relay, which is simply a relay in which the contact springs are not all operated at the same time. Thus, when a handset is removed from the cradle at a calling telephone, the corresponding line relay operates only part of its spring contacts. At a later time (when the calling line has been found by a finder and extended through to the succeeding switch), other circuit conditions cause the line relay to operate the remainder of its spring contacts.

(d) Twin Contact Relay

Twin contact relays, as the name implies, have two contacts on each spring, instead of just one. Such relays are sometimes used to minimize the possibility of contact failure due to dust, etc.

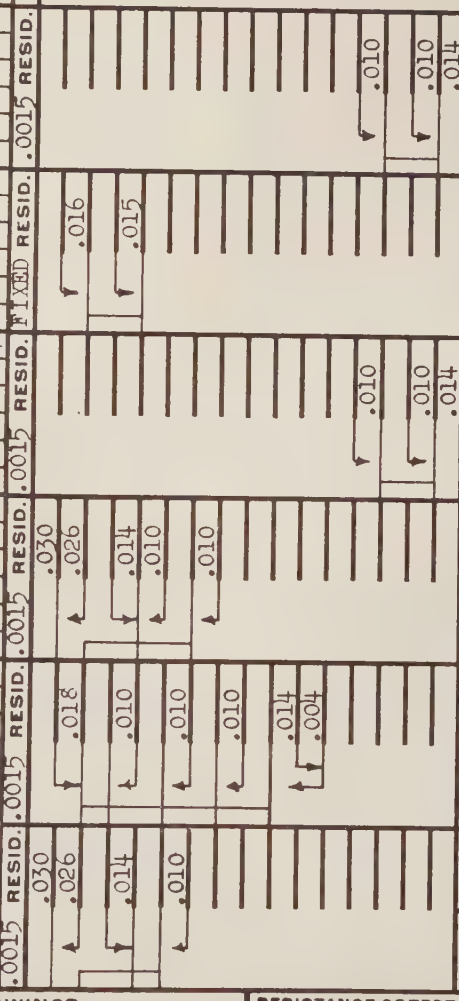
(e) Type "Z" Relay

A type "Z" relay is a special relay designed to occupy a smaller space than the standard horizontal relay. The saving in space is achieved mainly by having the contact springs located at the armature end of the heelpiece, instead of at the mounting end, which permits the use of a shorter heelpiece and coil.

F-1461 (8-32)

2-4-42
ISSUE 5

# Fig. A23 TYPICAL "AH" SHEET




| RELAYS | | TEST FOR | RESISTANCE READJ. | RESISTANCE TEST | CURRENT READJ. | CURRENT TEST | SEE NOTE | TESTING INSTRUCTIONS |
|---|---|---|---|---|---|---|---|---|
| NI FIG. 1 | NO. 1 | 0 | 6400 | 5400 | .0048 | .0053 | | POS. TO LOWER COIL TERM. OF RLY. N1. |
| RT-21-C9 | | NO | 7500 | 8700 | .0043 | .0038 | | |
| D-280400 | NO. 2 | | | | | | | |
| #1-3300ω | | | | | | | | |
| P1 | NO. 1 | 0 | 9400 | 8400 | .0040 | .0044 | | NEG. TO COIL TERM. 2 OF RLY. P1. |
| R-3032-A7 | | NO | 10500 | 11600 | .0036 | .0033 | | |
| D-282271 | NO. 2 | | | | | | | |
| #1-2150ω | | | | | | | | |
| A.C. | | | | | | | | |
| A2&E4 FIG. 2&4 | NO. 1 | 0 | 440 | 410 | .103 | .110 | | RLY. E4 SAME AS RLY. A2. |
| RT-215-A1 | | NO | 520 | 570 | .087 | .080 | | RLY. A2:-INS. SPGS. 3&4 OF RLY. B2. |
| D-281532 | NO. 2 | | | | | | | POS. TO SPG. 3 OF RLY. D2. |
| #1-6.3ω | | | | | | | | RLY. E4:-INS. SPGS. 3&4 OF RLY. F4. |
| #2-1000ω | | | | | | | | POS. TO SPG. 3 OF RLY. H4. |
| B2&F4 | NO. 1 | 0 | 2800 | 2450 | .0121 | .0133 | 4 | RLY. F4 SAME AS RLY. B2. |
| R-208-A4 | | NO | 3200 | 3600 | .0110 | .0100 | | RLY. B2:-POS. TO SPG. 1 OF RLY. A2. |
| D-283001 | NO. 2 | 0 | 1050 | 850 | .0227 | .0251 | | RLY. F4:-POS. TO SPG. 1 OF RLY. E4. |
| #1-1000ω | | NO | 1350 | 1600 | .0197 | .0178 | | INS. SPGS. 3,4&5 OF RLY. BEING TESTED. |
| #2-980ω | | | | | | | | POS. TO SPG. 2 OF RLY. BEING TESTED |
| D2&H4 | NO. 1 | 0 | 500 | 350 | .031 | .034 | | RLY. H4 SAME AS RLY. D2. |
| RT-334-A4 | | NO | 1000 | 1200 | .0230 | .0209 | | RLY. D2:-INS. SPGS. 3&4 OF RLY. B2. |
| D-283001 | NO. 2 | | | | | | | POS. TO SPG. 9 OF RLY. D2. |
| #1-1000ω | | | | | | | | RLY. H4:-INS. SPGS. 3&4 OF RLY. F4. |
| #2-980ω | | | | | | | | POS. TO SPG. 9 OF RLY. H4. |
| L3A FIG. 3 | NO. 1 | 0 | 48V | 50V | | | 8 | #1 TEST FOR #1 SPG. ONLY IN SERIES WITH |
| RT-234-A3 | | NO | 46V | 44V | | | | 4200 OHMS. INS. SPGS. 1&2 OF RLY. L3A. |
| D-280393 | NO. 2 | 0 | 2000 | 1700 | .0139 | .0153 | 8 | GRD. TO SPG. 1 OF RLY. L3A. |
| #1-1300ω | | NO | 2600 | 3000 | .0118 | .0107 | 8 | INS. SPGS. 1&2 OF RLY. L3A. |
| | | | | | | | | GRD. TO SPG. 2 OF RLY. L3A. |

**ASSOCIATED DRAWINGS**

EXPLANATION OF TERMS

#1—INSIDE OR ARMATURE END WINDING. #2—OUTSIDE OR HEEL END WINDING. S. A.—SLOW TO OPERATE & SLOW TO RELEASE: S. R.—SLOW TO RELEASE: S. O.—SLOW TO OPERATE: E. P.—ELECTRO POLAR: A. C.—ALTERNATING CURRENT. W.—BRASS WASHER BETWEEN COIL & HEEL PIECE. O.—OPERATE: N. O.—NON-OPERATE VALUES. RESID.—RESIDUAL ADJUSTMENT VALUE. TEST VALUES ARE FOR INSPECTION ONLY. READJ. VALVES ARE FOR ADJUSTING ONLY. CURRENT IS SHOWN IN AMPERES. RESISTANCE VALUES ARE FOR 46 V. BATTERY. POS.—TEST WITH POSITIVE BATTERY THRU RESISTANCE OF TEST SET. NEG.—TEST WITH NEGATIVE BATTERY THRU RESISTANCE OF TEST SET.

NOTES

1—TEST WITH BOTH WINDINGS IN SERIES.
2—TEST WITH VERTICAL MAGNET IN SERIES.
3—TEST WITH ROTARY MAGNET IN SERIES.
4—NO. 1 WINDING TO OPERATE NO. 1 SPRING ONLY.
5—SPRINGS NEED ONLY MAKE CONTACT ON OPERATE TESTS.
6—BOTH TESTS MADE ON NO. 1 WINDING. NO. 1 TEST IS FOR NO. 1 SPRING ONLY.
7—CONNECT RESISTANCE ACROSS TEST JACKS 1 & 2.
8. REMOVE LEAD FROM LOWER COIL TERM. OF RLY. L3A & CONNECT NEG.

| STANDARD ADJUSTMENTS | | | | 101 | 101 | 110 |
|---|---|---|---|---|---|---|
| 118 | 151 | 173 | 753 | | | |

TYPE.- RJ | ENG.- | APP'D.- | OK.-

AUTOMATIC ELECTRIC COMPANY
CHICAGO, U.S.A.

**RELAY ADJUSTMENT SHEET**

POWER CIRCUITS RING. & TONE
MACHINE TIMER & ALARMS
A.C. SERVICE 48 VOLTS

CKT.- GH-35992 | 5 SHEETS | 1

AH-35992

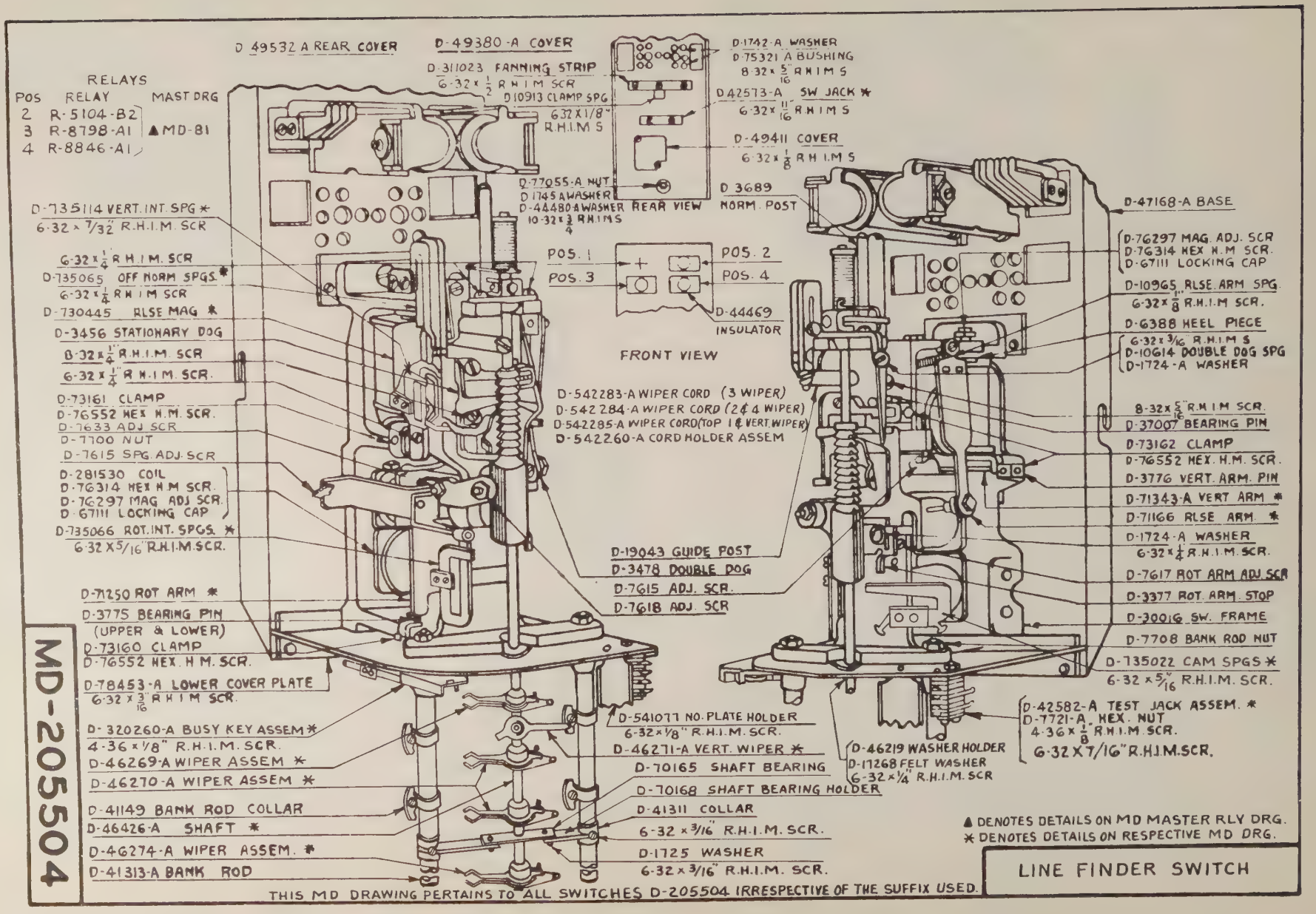



Fig. A24 TYPICAL "MD" DRAWING

# YOUR 1949 OPPORTUNITIES

For ALL employees (MEN AND WOMEN) of Automatic Electric & Associated Organizations.

TIME - 5 to 6 P.M. PLACE - A. E. Co. Cafeteria

SPONSORED BY - Strowger Automatic Club - Educational Committee

"WHAT DO WE LIVE FOR IF IT IS NOT TO MAKE LIFE LESS DIFFICULT FOR EACH OTHER?"

GEORGE ELIOT

(WHEN) (WHAT) (WHY)

| DATES | TUITION IN ADVANCE | EDUCATIONAL COURSES | INSTRUCTORS |
|---|---|---|---|
| (MONDAYS) | | **1. CIRCUIT KINKS** (10 lectures) | ★ HARRY E. HERSHEY (Started A.E.Co. 1910) |
| Jan. 31<br>Feb. 7<br>14<br>21<br>28<br>Mar. 7<br>14<br>21<br>28<br>Apr. 4 | *<br>$3<br>**<br>$5 | Description of Course (COVERS PAGES 77 TO 93)<br>(SIGNIFICANT FUNDAMENTALS on which ALL Automatic Telephone Circuits are built.) (SUITABLE FOR BEGINNERS)<br>* For those already having a copy of the book "AUTOMATIC TELEPHONE PRACTICE" (However acquired).<br>** For new students. (They will be given a copy of Harry E. Hershey's book.) | BACKGROUND<br>* Student Course<br>* Installation<br>* Patents<br>* Factory Inspection<br>* Advertising<br>* Laboratories<br>* Sales<br>* Operating<br>* Conducted training school for Bell equipment engineers from all over U.S.<br>* Equipment Engineering<br>* HEAD, Technical Publications<br>* Author * Inventor<br>* Engineer * Teacher<br>* Lawyer |
| (WEDNESDAYS) | | **2. ADVANCED STROWGER AUTOMATIC TELEPHONY** (10 lectures) | ★ IMRE MOLNAR (Started A.E.Co. 1930) |
| Feb. 2<br>9<br>16<br>23<br>Mar. 2<br>9<br>16<br>23<br>30<br>Apr. 6 | $3 | Continuation of ELEMENTARY STROWGER TELEPHONY<br>Description of course<br>Further elaboration of central office equipment<br>Main automatic exchanges<br>Fundamentals of traffic<br>Elementary trunking schemes<br>Party line operation, reverting calls, PBX trunk hunting, paystation operation<br>Repeaters<br>Pulsing schemes<br>Community automatic exchanges<br>Discussions | BACKGROUND<br>*Installation<br>*Circuit design<br>*Transmission engineering<br>*Resident engineer in several foreign countries<br>*Project engineer<br>*General development work in laboratory<br>*Responsible for many communication developments in manual, automatic, long distance, voice frequency systems, carrier current systems, etc. |
| (FRIDAYS) | | **3. INTER-TOLL DIALING AND TICKETING** (10 lectures) | ★ JOHN E. OSTLINE (Started A.E.Co. 1922) |
| Feb. 4<br>11<br>18<br>25<br>Mar. 4<br>11<br>18<br>25<br>April 1<br>8 | $3 | Description of Course<br>Operation of Director<br>Correlation of Director operation with toll dialing<br>Correlation of Director operation with toll ticketing | BACKGROUND<br>* U.S.A. Operating Field<br>District Wire Chief<br>Plant Engineer<br>Traffic Engineer<br>* LONDON<br>Supervising Res. Engineer<br>Director Conversion<br>* NEW YORK Bell Labs.<br>Cooperative Circuit Design<br>* BELGIUM<br>Designed first T.T. System<br>* CHICAGO<br>A.E. Labs.<br>Director, Automatic Call Ticketing and Toll Dialing |

★ COMPETITION IS GETTING KEENER. ARE YOU?

**LETS HIT THIS LINE IN FORTY-NINE**

U
10
9
8
7
6
5
4
3
2
1
50